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EDAPTS Benefit/Cost Evaluation

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CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

EDAPTS

Smart Transit System

EDAPTS Benefit/Cost Evaluation

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Abstract

This technical report summarizes the benefit/cost evaluation of the SLO Transit EDAPTS ITS system. It provides a detailed description of the methodologies and procedures used, as well as the research findings resulting from the evaluation effort.

Using passenger questionnaire, boarding time surveys and interviews with SLO Transit drivers and administrators, the research team collected and estimated various benefits and costs of the SLO Transit EDAPTS system and conducted a benefit/cost (B/C) ratio analysis on the EDAPTS system. Also the research team performed a sensitivity analysis of B/C ratios to different discount rates and service lives of the EDAPTS system. The ratios of annual benefits to annual costs are at least 3.9:1 for the SLO Transit EDAPT ITS system. This strongly indicates that the EDAPTS ITS technologies are economically viable.

Keywords: Advanced Public Transportation System, Benefit/Cost Evaluation, Efficient Deployment of Advanced Public Transportation Systems (EDAPTS

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EXECUTIVE SUMMARY

In the late 1990s, the California Department of Transportation (Caltrans) embarked on a research program entitled “Efficient Deployment of Advanced Public Transportation Systems (EDAPTS).” The objective of this program was to make low-cost, easily deployed Intelligent Transportation System (ITS) technologies readily available to small and medium size transit properties.

In early 2001, the first EDAPTS ITS system was installed, tested, and began operation at San Luis Obispo (SLO) Transit. The system utilizes innovative digital communications links, open source designs, solar powered real-time arrival signs, and innovative data links to improve transit services and safety for passengers and drivers. This successful system test supports commercializing the EDAPTS approach if it can also be evaluated to be economically sound for small/medium transit providers.

Recognizing the need for an economic justification for commercialization, Caltrans in 2005 initiated three additional research projects for the EDAPTS program. These three projects are 1) Benefit/Cost (B/C) Evaluation of the EDAPTS ITS System at San Luis Obispo Transit (herein referred to as the B/C Evaluation Project), 2) Development of Performance-Based Specifications for EDAPTS, and 3) Bronco Express Demonstration of EDAPTS for the university shuttle bus system at California State Polytechnic University, Pomona (Cal Poly Pomona). The collective goal of these projects is to solidify the business case for EDAPTS and, if possible, demonstrate to the transit community that using the EDAPTS approach is just “smart business practice.”

This technical report, a result of the B/C Evaluation Project, summarizes the benefit/cost evaluation of the SLO Transit EDAPTS ITS system. It provides a detailed description of the methodologies and procedures used, as well as the findings resulting from the evaluation effort.

The researchers on the B/C Evaluation Project first conducted a literature review on benefit/cost studies done for Advanced Public Transportation Systems (APTSs), then determined appropriate benefit and cost measures of performance (MOPs) for the EDAPTS ITS system. Using these MOPs as guidelines, the researchers developed an innovative evaluation method (based on stated preference analysis) to quantify the intangible benefits of the system. This stated preference evaluation method uses the principle of *willingness-to-pay* to provide an aggregate measure of what surveyed passengers are willing to forego to obtain a given ITS service feature. This research could be the first application of quantifying benefits of ITS technologies using the stated preference evaluation method.

Using a passenger questionnaire, a boarding time survey, and interviews with SLO Transit drivers and administrators, the research team estimated the various benefits and costs of the SLO Transit EDAPTS system. On this basis, a benefit/cost (B/C) ratio analysis was performed. The team also performed a sensitivity analysis of B/C ratios considering different discount rates and assumed service lives of the EDAPTS system.

The study considered that there are two basic types of benefits generated by the SLO Transit EDAPTS system: conventional benefits and consumer surplus. Conventional benefits are the benefits directly measured using the "willingness to pay" principle for existing passengers, as well as for drivers and SLO Transit administrators. Consumer surplus is the difference between the price consumers (passengers) are willing to pay and the actual price charged by the SLO Transit.

The analysis used a 7% discount rate (as required by the US Office of Management and Budget (OMB) for public investment projects) for the B/C ratio analysis. Table ES-1 presents a summary of the benefit-cost ratios for the assumed 5-year, 7-year, and 10-year service lives (or terms) of the EDAPTS system. For each term, two ratios are presented, corresponding to whether the consumer surplus is included in the user benefits or not. The most conservative B/C ratio analysis excludes consumer surplus as benefits and shows B/C ratios of approximately 3.9 to 5.7. This indicates in general that every dollar invested in the SLO Transit EDAPTS system resulted in at least four dollars of benefits to the constituent groups. Considering consumer surplus as benefits makes the B/C ratios increase to between 4.8 and 7.0.

Table ES-1 Benefit/Cost Ratio Summary (with 7% Discount Rate)

	5-Year Term	**7-Year Term**	**10-Year Term**	**Units**	**Constituent**
Including Consumer Surplus					
Total of All Benefits	$226,581	$226,581	$226,581	$ per year	All beneficiaries
Total Costs	$46,954	$38,488	$32,222	$ annualized	transit agency
Benefit to Cost Ratio	4.8	5.9	7.0		
Excluding Consumer Surplus					
Total of All Benefits	*$183,934*	*$183,934*	*$183,934*	*$ per year*	*All beneficiaries*
Total Costs	*$46,954*	*$38,488*	*$32,222*	*$ annualized*	*transit agency*
Benefit to Cost Ratio	*3.9*	*4.8*	*5.7*		

Table ES-2 presents further results of the B/C ratio sensitivity analyses. When consumer surplus is included in the benefits, ratios range from 4.8 to 7.0. Without consumer surplus, ratios range from 3.9 to 5.7. This table shows how the ratios change when service lives increase from the shortest (5-year) to the longest (10-year) and when discount rates change from 5% to 10%. As discount rates go up, B/C ratios decrease slowly. This indicates that the B/C ratios are not very sensitive to discount rates. They substantially exceed 1.0 in all cases and certainly provide economic justification for continuing efforts to commercialize EDAPTS ITS technologies.

Table ES-2 Sensitivity Analysis of Benefit/Cost Ratios

	5-Year Term	7-Year Term	10-Year Term
Including Consumer Surplus			
5% Discount Rate	5.0	6.2	7.5
7% Discount Rate	4.8	5.9	7.0
10% Discount Rate	4.5	5.5	6.4
Excluding Consumer Surplus			
5% Discount Rate	4.1	5.0	6.1
7% Discount Rate	3.9	4.8	5.7
10% Discount Rate	3.7	4.4	5.2

It is concluded from this research that the findings provide a strong economic basis to recommend the deployment of EDAPTS ITS technologies for small/medium size transit agencies. Some additional findings are described below:

1) Passengers of SLO Transit, as indicated from the questionnaire surveys, perceived substantial benefits from the EDAPTS ITS features. For example, 16% of respondents concurred that the bus arrival time displays did effect their decisions to ride. Survey results indicated that there would be an 8.4% reduction in rides if there were no bus arrival time displays at stops. This indicated that the presence of the bus arrival time displays at stops indeed produces benefits in terms of ridership retention or gain.

2) Not all EDAPTS ITS features were recognized as directly beneficial by passengers, drivers and SLO Transit management. For instance, passengers were largely unaware of Global Positioning System (GPS) receivers on buses, and drivers and dispatchers valued the use of radios in emergencies over GPS. However, the GPS data did provide real-time information to SLO Transit in dealing with dispatching, schedule adherence, emergency responses, and passenger complaints.

3) More people were willing to pay for an alternative transportation mode when faced with a service shut-down than for a substitute when service was simply delayed. People were willing to pay about 40% more on average for an alternative transportation mode when faced with service disruption than with a delay in service. It is quite revealing to note that typical riders were only willing to pay as much for an alternative mode as the cost of a one-way bus fare.

4) Surveys of passenger boarding times on buses indicated that boarding times vary among different payment types. On average, the Cal Poly ID swipe card, a SLO Transit EDAPTS ITS feature, exhibited a clear time advantage over the use of other payment media by an

average of 3.9 seconds per boarding. This indicates that using the Cal Poly ID swipe card to board buses can save substantial boarding times and in the long run facilitate schedule adjustments for reduction of bus running times.

5) At a total initial investment of less than $150,000, small and medium-size transit agencies can deploy EDAPTS ITS features relatively inexpensively, as demonstrated by the test deployment at SLO Transit. The annualized capital, operational and maintenance costs range from $30,000 to $50,000 for an EDAPTS ITS system with a service life from 5 years to 10 years.

6) The total annual benefits generated from an EDAPTS ITS system, as identified in this research, could range from $185,000 to $225,000. This does not include additional benefits (such as civic pride) that cannot be easily quantified in dollars. The annual benefits substantially outweigh the annual costs.

7) The ratios of annual benefits to annual costs are at least 3.9:1 for the SLO Transit EDAPT ITS system. This strongly indicates that the EDAPTS ITS technologies are economically viable.

In summary, this research conducted a comprehensive benefit/cost (B/C) ratio evaluation for the SLO Transit EDAPTS ITS system. The findings confirm that the EDAPTS ITS technologies indeed are a low-cost, easily deployed, economically sound ITS solution for small/medium transit agencies.

1. INTRODUCTION

Transit users in small urban and rural communities face significant problems when using transit for primary transportation needs. In response to this, the California Department of Transportation (Caltrans) embarked on a research program entitled "Efficient Deployment of Advanced Public Transportation Systems" (EDAPTS) in the late 1990s. The goal was to make lower-cost, easily deployed Intelligent Transportation System (ITS) technology more available to the small transit community. In early 2001, a California Polytechnic State University at San Luis Obispo (Cal Poly SLO) research group, led by Jeff Gerfen, teamed with San Luis Obispo Transit (SLO Transit) on this innovative research project. The research team installed, tested, and operated the first successful EDAPTS ITS system using SLO Transit vehicles and facilities for the test-bed deployment. It utilized innovative digital communications links, open source designs, solar powered real-time arrival signs, and innovative data links to drastically lower life-cycle costs for the transit agency and improve service and safety for the passengers and drivers. This successful project pointed out the need for commercialization of the EDAPTS approach if it is to be a viable ITS solution path for small transit providers.

Recognizing the potential benefits of the SLO Transit EDAPTS test, Caltrans initiated three additional research projects for the EDAPTS program in 2005. These three projects are 1) Benefit/Cost Evaluation of the EDAPTS system at San Luis Obispo Transit (herein referred to as the B/C Evaluation Project), 2) Development of Performance-Based Specifications for EDAPTS, and 3) Bronco Express Demonstration of EDAPTS for the university bus system at California State Polytechnic University, Pomona (or later called Cal Poly Pomona). The collective goal of these projects is to solidify the business case for EDAPTS and demonstrate to the transit community that using the EDAPTS approach is just "smart business practice" for them.

The underlying motivation of the B/C Evaluation Project is:

> *There is economic justification for pursuing EDAPTS commercialization efforts if the San Luis Obispo EDAPTS Smart Transit System is shown to have a benefit/cost (B/C) ratio greater than "1.0."*

A B/C ratio substantially greater than 1.0 could be interpreted as an argument supporting a positive recommendation on commercialization and encouraging small transit properties to deploy low-cost EDAPTS ITS solutions in other locations. If the B/C ratio for EPAPTS on SLO Transit is found to be less than 1.0, it would be important to document lessons learned from this test deployment and make recommendations regarding the possible need for continued EDAPTS research activities. While the SLO Transit EDAPTS approach has demonstrated many benefits, it was not known at the start of this effort whether it has an overall benefit/cost (B/C) ratio sufficiently high to warrant consideration for widespread deployment and commercialization.

This B/C Evaluation project continues the initial EDAPTS analysis work undertaken by David Gillen of UC Berkeley and Ed Sullivan of Cal Poly San Luis Obispo (Gillen and Sullivan, 2002) during the initial research project at SLO Transit in 2001. The Gillen and Sullivan work studied the impact of the SLO Transit EDAPTS test deployment on the users and operations of SLO Transit. Due to the lack of applicable benefit and cost data for small transit ITS during the test deployment, Gillen and Sullivan conducted their own limited benefit/cost analysis for use in their study. The current research effort compliments the original Gillen and Sullivan work, with more consideration given to identifying, collecting, and evaluating the costs and benefits of the SLO Transit EDAPTS system for riders, drivers, transit management, and the surrounding community.

This research project performed the following tasks for the B/C evaluation of the SLO EDAPTS system:

Task 1 Conducted a literature review on benefit/cost studies done on Advanced Public Transportation Systems (APTSs). The outcome of this literature review is a report that identifies and summarizes the characteristics of existing APTS applications that were developed and deployed by transit properties, and then analyzed using benefit/cost analysis techniques.

Task 2 Determined appropriate benefit and cost measures of performance (MOPs) for the EDAPTS system. The selected MOPs covered both tangible and intangible measures and were selected to reflect the perspectives of riders, drivers, dispatchers, and system managers. The outcome of this task is a MOP matrix that lists all the cost and benefit measures developed.

Task 3 Performed cost data collection and estimated tangible and intangible costs. These costs included system costs, user costs, operational costs, and maintenance costs. The outcome is a data set that stored the cost information for the EDAPTS system.

Task 4 Performed benefit data collection and estimated direct and indirect benefits for the EDAPTS system. The outcome is a data set that summarizes the benefit information for the EDAPTS system.

Task 5 Conducted a benefit/cost (B/C) ratio analysis on the SLO Transit EDAPTS system and performed sensitivity analysis of B/C ratios to different discount rates and service lives of the EDAPTS system. With the benefits and costs quantified and converted to equivalent annual values, the research team conducted the benefit/cost evaluation and determined how much the B/C ratio would change with systematic changes to discount rates and service life.

Task 6 Published the present final report detailing the findings of the research project. The findings in the report justify the need to continue efforts to commercialize the EDAPTS ITS approach for small transit operators.

Task 7 Presented findings to Caltrans personnel on what the B/C Evaluation project found and how those findings impact the on-going efforts to commercialize EDAPTS. The presentation occurred at an interactive meeting at the Caltrans office in Sacramento.

This technical report documents the full benefit/cost evaluation of the SLO Transit EDAPTS system and provides a detailed description of the methodologies and procedures used, as well as the research findings resulting from the evaluation effort. It is organized into ten sections, the first of which is this introduction. Section 2 summarizes the literature review that was undertaken to discover past benefit/cost research work on the evaluation of similar Advanced Public Transportation Systems (APTS) applications. Section 3 describes selected methodologies used for the B/C Evaluation project. Section 4 documents the full list of benefit and cost measures of performance (MOPs) used in the work. These methodologies and MOPs established the framework for benefit and cost data collection. Sections 5 and 6 cover the data collection effort using several types of surveys and interviews. Section 7 describes the complete B/C analysis of the collected data. The major findings and the conclusions of the B/C analysis are documented in Section 8. Section 9 provides a list of references and Section 10 contains appendices that describe the Passenger Survey Instrument, the Passenger Boarding Time Survey program, the Driver Interview Guide, the Administrator Interview Guide, and background information pertaining to the selection of discount rates.

Through these results, transit properties can better understand how low-cost ITS solutions can improve their operations, and potential integrators will have a clear picture of the performance of an EDAPTS-derived ITS solution. It is anticipated that together, the results of these three projects will establish a solid foundation for future Caltrans decisions regarding the need for EDAPTS commercialization.

2. LITERATURE REVIEW

Advanced Public Transportation Systems have been increasingly developed by transit properties as a means of 1) increasing the efficiency and safety of transit services, 2) offering users easy access to real-time information about transit operations, and 3) providing reliable customer services. In order to understand the economic justification of APTS applications, researchers have conducted a number of benefit/cost (B/C) studies to assess the use of APTS technologies in transit properties (Gomez, Zhao, and Shen, 1998; Wallace, 1999; Furth and Muller, 2000; Lehtonen and Kulmala, 2002; Gillen et al 2002; Gillen and Sullivan, 2002; Daigle and Zimmerman, 2003; Peng, Zhu and Beimborn, 2005).

After reviewing these B/C studies, this project found that there had been two types of research efforts relevant to APTS benefit/cost evaluation. One type of effort was centered on identifying the specific benefits and costs associated with the implementation of APTS systems as well as frameworks for evaluating these benefits and costs. These benefits and costs are normally grouped into the six categories: Safety, Mobility, Productivity, Efficiency, Energy and Environment, and User Satisfaction. The other type of effort was aimed at developing appropriate methodologies for measuring benefits and costs that are not easily quantified.

In a typical benefit/cost evaluation study, costs are usually straightforward and are more easily identified and measured while benefits are much more difficult to identify and quantify. In considering the nature of benefit/cost evaluations, this literature review emphasized the search not only for tools and procedures to identify benefits and costs but also for methodologies that would have potential in the economic assessment of the SLO EDAPTS ITS system.

2.1 Review of APTS Evaluation Frameworks and Applications

Economic justification and a positive return on investment are critical to the successful deployment of APTS technologies in transit properties, and especially in the small transit environment. As the economic justification often involves the evaluation of benefits and costs associated with a specific suite of APTS applications, the US Department of Transportation (DOT) has, for more than a decade, been actively collecting information regarding the impact of APTS implementations. Researchers also have conducted a number of benefit/cost assessment studies on APTS applications for various transportation agencies throughout the nation (FHWA, 2003; FHWA, 2005).

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APTS Benefit/Cost Database

In helping justify the deployment of Intelligent Transportation Systems (ITS) applications, the ITS Joint Program Office (JPO) of the US Department of Transportation (DOT) sponsored the development of the ITS Benefits and Costs Databases. The databases are located at http://www.benefitcost.its.dot.gov and are available to the public. The databases contain the most recent data collected by the JPO and are a central repository of existing knowledge of ITS benefits and costs for transportation professionals. The databases also provide the research community with information on ITS areas where further analysis may be required. The

Benefits and Costs databases website contains detailed summaries for each ITS evaluation report stored in the databases. The summaries provide additional background on the context of the evaluations, the evaluation methodologies used, and links to the source documentation. The JPO requires any ITS evaluation reports submitted for inclusion in the databases to meet its acceptance criteria (see Mitretek Systems, 2000).

Caltrans Guide to Benefit/Cost Analysis

In order to assist practitioners in the correct conduct of benefit/cost analysis for transportation investments, including ITS projects, the Caltrans Division of Transportation Planning, Office of Transportation Economics, recently published an on-line guide to concepts and methods in this area. The guide is located at *http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/*. In addition to providing useful information on the conduct of these analyses in general, the guide also provides descriptions and links to modeling software created for a range of benefit/cost applications, including software specifically designed for ITS evaluations.

Specific Benefit/Cost Applications

There have been many benefit/cost studies since ITS technologies were applied in transit industry. In these benefit/cost studies, researchers have related the use of APTS technologies to improvements in transit operational services and found that APTS technologies can be beneficial to transit properties with large fleets. However, there have been few benefit/cost analyses of APTS applications in small or medium sized transit properties and the few publications in existence acknowledge the difficulty of measuring particular benefits of APTS systems. Some of these researchers are:

Gomez, Zhao, and Shen evaluated the benefits of transit Automatic Vehicle Location (AVL) systems and their implementation in the U.S. (Gomez, Zhao, and Shen, 1998). They concluded that AVL applications in public transit systems have many benefits to transit agencies and riders, including improving on-time performance, raising productivity, enhancing security, and increasing ridership. AVL can provide real-time information about bus locations, running speed and other information. Transit dispatchers can use real-time information for bus scheduling and transit planners can use real-time information for adjusting transit routes and stops. Transit users can benefit from improved on-time performance and schedule reliability, as well as real-time information to reduce waiting time and anxiety. Their research showed that transit riders are extremely sensitive to schedule reliability and the improved arrival-time reliability arising from the use of AVL could potentially increase transit ridership and improve service satisfaction.

Wallace, Richard R. et al assessed the impact of several transit safety and security enhancements based on a 1998 survey of transit riders in Ann Arbor, Michigan (Wallace, 1999). The safety and security enhancements evaluated included on-board video surveillance, emergency phones, video cameras at transit centers, enhanced lighting at transfer centers and increased police presence. Surveys were taken of riders on randomly selected routes at random times during weekday service.

They found that camera systems were the safety enhancement most often noticed by respondents. When respondents rated the degree to which improvements increased their sense of security, police presence showed the greatest influence, followed closely by increased lighting. Emergency phones and video cameras had smaller impacts.

Furth and Muller measured the effectiveness of a transit signal priority system installed in the City of Eindhoven (population 300,000), the Netherlands (Furth and Muller, 2000). The signal priority system was installed in all local transit vehicles. The adherence of the vehicle to its optimal schedule was monitored. "Early" or "late" status was communicated to the vehicle operator. Video cameras were mounted on utility poles at the busiest intersection in order to measure the impacts of the signal priority system on overall traffic delay. Also, buses were equipped with onboard computers and wireless communications to track schedule adherence.

The effectiveness of the transit priority system was determined by measuring the difference in the deviation of individual vehicles from their schedule as they passed through signalized intersections. The project compared the on-time performance of vehicles when the transit priority system was in use as compared to when the system was not in use. Performance data on schedule deviation, run times, and delay were downloaded from the computer to evaluate schedule adherence and bus delay.

This research showed that vehicular delays for traffic under conditional priority (or the priority to a bus running behind schedule) were about the same as those for traffic with no bus priority. The absolute priority (or the priority to provide a green phase to each bus regardless of whether or not it was running ahead of schedule) caused large increases in delay. This research also found a strong improvement in schedule deviation during periods with conditional priority compared to periods with no priority.

Lehtonen and Kulmala evaluated a pilot project designed to provide real-time passenger information and signal priority to tram and bus lines in the City of Helsinki, Finland (Lehtonen and Kulmala, 2002). Automated Vehicle Location (AVL) and Computer Assisted Dispatch (CAD) systems were installed in a pilot project. Their study showed that the system had positive effects on the level-of-service for tram and bus services. Based on their test ride observations, in-vehicle studies and ticket sales information, the pilot project showed increases in on-time performance and ridership, reductions of travel time, fuel consumption and mobile emission, as well as improvements in user satisfaction.

Gillen and Sullivan conducted an evaluation of the EDAPTS impacts on riders and services provided by the San Luis Obispo (SLO) Transit (Gillen and Sullivan, 2002). They evaluated bus operations prior to and after the deployment of the EDAPTS ITS technologies and conducted surveys of riders. Using limited operational data, they were able to identify a set of positive system benefits to the transit operator, employees, riders, and the community at large.

Daigle and Zimmerman did a Field Operational Test (FOT) on the deployment of ITS traveler information on shuttle buses at the Acadia National Park in Maine (Daigle and Zimmerman, 2003). ITS technologies that were evaluated by their project included Automated Vehicle Location (AVL), real time electronic arrival signs, automated in-vehicle annunciation systems, automated in-vehicle passenger counting systems, and website and telephone traveler information services. These technologies were deployed as a way to disseminate more accurate and timely information to more than two million park visitors each year. The primary goal of the study was to measure the impact of ITS on the "quality of visitors' experience" in terms of customer satisfaction and mobility. Visitors were asked about their awareness, use and experience with ITS in the park.

The findings from their study were that ITS helped the free shuttle bus service, Island Explorer, improve shuttle bus operations, reduce parking lot congestion, and improve aesthetics and safety by decreasing the number of vehicles parked alongside roads. Also, the ITS enhanced the growing tourist economy through improved mobility.

Peng, Zhu and Beimborn investigated the use of AVL systems to enhance transit performance, management and customer services in two medium-sized transit agencies (Peng, Zhu and Beimborn, 2005). This investigation was based on surveys conducted in Racine and Waukesha, Wisconsin before and after AVL implementation and in Manitowoc, Wisconsin, a small city without AVL. This research found that features like improving on-time performance, knowing when the bus will arrive, knowing that another bus will be dispatched in case of breakdown were valued as important to transit users. This research also observed that transit system with AVL have improved schedule adherence and on-time performance. The researchers concluded that more passenger trips (i.e. increased ridership) would be realized if better information were offered to users.

The evaluation studies described above included large, medium and small transit properties. They all showed that APTS applications provided a set of benefits including the improvement of on-time performance, the reduction of users' wait time and anxiety, and the improvement of user satisfaction. However, these studies did not place their focus on the comparison of benefits to costs for APTS applications, as is generally recommended in the accepted benefit/cost (B/C) analysis guidelines. Few studies measured benefits and costs in dollars and calculated benefit/cost ratios for APTS applications.

It is concluded from the review of the previous APTS evaluation studies that the challenges in economic evaluation of APTS applications are likely due to the lack of effective evaluation methods for placing dollar values on benefits that are not easily quantified. Quantifying benefits in dollar values requires creative assumptions and stated preference surveys that will be described in later sections.

2.2 Review of APTS Evaluation Methods

A few evaluation methods and tools show high potential for dollar-quantified assessment of APTS applications. These methods and tools are grouped in this report into two categories: Conventional Methods and Market Study Methods.

Conventional Methods

The ITS Deployment Analysis System (IDAS) is one of the conventional methods. Developed by the Federal Highway Administration (FHWA), it has been widely used in planning for Intelligent Transportation System (ITS) deployments. This method evaluates the benefits and costs of ITS investments by integrating with outputs of existing transportation planning models, comparing and screening ITS deployment alternatives, and estimating the impacts and traveler responses to ITS.

The IDAS method provides a set of default values for benefits and costs. These default values are the initial inputs for evaluating travel time, fuel consumption and other impacts in dollar values, making the IDAS method an effective tool for benefit/cost evaluation of ITS applications. However, it has certain limitations when used for evaluating APTS applications. A test conducted by the Chicago Area Transportation Study (CATS) in 2003 showed that IDAS provides a set of reasonable analysis methodologies for highway networks. It is therefore well suited for elevating ITS deployments on highways. Due to the fact that IDAS cannot perform transit network assignments, it can only analyze benefits and costs of transit services at an aggregate (zonal) level. Also, the IDAS method requires a substantial level of effort in preparing all the necessary data inputs for IDAS. Additionally, some of the IDAS default values might not be applicable to APTS applications. It seems that making direct use of the IDAS model for evaluating APTS applications is not appropriate for the present study.

Market Study Methods

Market study method offers potential for effective evaluation of APTS applications. Two types of approaches for B/C evaluations are hedonic pricing models and contingent valuation methods. Hedonic pricing models measure imputed values in the revealed preferences of consumers. Contingent valuation methods measure stated preferences of consumers. In general, these two types of market study methods use information such as people's behavior to measure their willingness to pay (WTP) for services and/or technologies when faced with situations of choice.

1) Hedonic Pricing Models

Hedonic price models are considered a potential tool for measuring benefits associated with EDAPTS because, as Williams (1991) asserts, “it can be used as a means to value indirectly non-market effects” and many of the benefits of the EDAPTS approach are envisioned to be indirect and not readily measurable. Hedonic pricing models are based on the concept that goods comprise bundles of attributes that combine to form objectively measurable characteristics or utility-affecting attributes that consumers value (Leong and Chau, 2002). For instance, in the real estate market, where much of the literature on hedonic models is published, the hedonic method uses information on people's choices to estimate their WTP for attributes related to housing location, structure or amenities and neighborhood (Diamond, 1980; Shaw, 1994; Leong and Chau, 2002). It is discernible that these attributes are both quantitative and qualitative. Even studies that specifically deal with transportation themes largely relate them to real estate location choices (Rosen, 1974; Dewees, 1976; Williams, 1991; Voith, 1991, 1993; Landis, Guhathakurta, William and Zhang 1995; Armstrong 1995; Cervero and Duncan, 2002; Heckman, 2003; Kawamura and Mahajan, 2005; Armstrong and Rodríguez, 2006). The primary effect of location choice is measured by accessibility to goods, services, activities and so on. A hedonic model allows one to infer from the model the marginal average willingness to pay for a unit of increased accessibility. Quantifying willingness to pay then becomes the basis for determining the benefit of increased accessibility or other benefits. In general, the hedonic model may be stated as follows:

The market price (*P*) of a property can be expressed as a function (*f*) of housing location (*L*) as measured by accessibility, structure or amenities (*S*), and neighborhood (*N*):

$$P = f(L, S, N)$$

The partial derivative of this hedonic function with respect to any of the attributes, all else equal, is the implicit marginal attribute price (or benefit) of the particular attribute (Rosen, 1974). The functional relationship investigated is of the general form:

$$Y_i = \alpha + \beta X_i + \varepsilon_i$$

Where:

Y_i - a measure of market value of the i^{th} property;

α - the intercept term standing for the effect of excluded variables on the value of the property;

β - a vector with the estimated implicit marginal price for each attribute k; X_i is a vector of measures of k property attributes; and

ε_i - denotes stochastic error terms

2) Contingent Valuation Methods

Studies of existing markets using hedonic price models are limited because only choices made by consumers can be used to infer the values of the attributes of goods. Stated preference surveys can apply contingent valuation or ranking of attributes to estimate the benefits of actions or policies that place people beyond the range of their choice-making experience (Louviere et al, 1981, 1986; Steer 1983; Kroes, 1990). For instance, transit riders may be asked to value or rank features of the EDAPTS ITS system (or APTS features in general).

In their book on using surveys and contingent valuation to value public goods, Mitchell and Carson (1989) expressed the following:

> *"Economists and others have long believed that by balancing the costs of such public goods as air quality and wilderness areas against their benefits, informed policy choices can be made. But the problem of putting a dollar value on cleaner air or water and other goods not sold in the marketplace has been a major stumbling block. The authors argue that at this time the contingent valuation (CV) method offers the most promising approach for determining public willingness to pay for many public goods---an approach likely to succeed, if used carefully, where other methods may fail. Placing contingent valuation in the larger context of welfare theory, the authors examine how the CV method impels a deeper understanding of willingness-to-pay versus willingness-to-accept compensation measures, the possibility of existence values for public goods, the role of uncertainty in benefit valuation, and the question of whether a consumer goods market or a political goods market (referenda) should be emulated."*

Consider the following survey question that asks the subject to quantify individual's willingness to pay for a private good (adapted from Johannesson, Johansson, and O'Conor, 1996). Contingent valuation may be illustrated as follows:

> *"In the U.S., about 1 in 5000 people dies annually in traffic. A possible measure to reduce the traffic risk is to equip cars with safety equipment, such as airbags. Imagine a new type of safety equipment. If this equipment is installed in your car, the risk of dying in a traffic accident will be cut in half for you and everyone else traveling in the car. This safety equipment must be tested and serviced each year to make sure that it is working correctly.*
>
> *Would you choose to install this safety equipment in your car if it will cost you $A per year?*
>
> *[YES or NO]*
>
> *Where $A might take on values of $30, $150, $300, $750, $1500, or $3000 for each survey respondent."*

> *A similar question which asks for the willingness to pay for a public policy might read (again, adapted from Johannesson, et al.):*

"In the U.S., about 1 in 5000 people dies annually in traffic. The number of deaths can be reduced if we devote more resources to preventing traffic accidents. We can, for example, straighten out turns, build safer crossings, and increase the supervision of traffic. Imagine a program that cuts in half the risk of your and everyone else's risk of dying in a traffic accident. Are you willing to pay $A per year more in taxes on your car for this program?

[YES or NO]"

With both questions that involve the stated preferences, the value of a statistical life is equal to the average willingness to pay divided by the reduced risk of death (dR). In this case (as is generally the case), the reduced risk of death is equal to the number of lives saved divided by the affected population. If the average WTP = $500 and dR = .0001 (1 in 10,000), then the "benefit" or value of (a saved) statistical life (VSL) = 500/.0001 = $5 million.

In measuring the benefits of the EDAPTS ITS system, the above-mentioned stated preference methods could be applicable if riders were observed to make travel-related financial decisions based on the features the EDAPTS ITS system provides. The readily observable factor in the EDAPTS ITS system experiment would relate to frequency or level of rides taken. Conceptually, increases in rides, if attributable to the features of the system, would be adjudged benefits and could be indirectly assigned monetary values. Using the stated preference method, riders could be surveyed about the features (or the services) that they would like to have (i.e. YES or NO) and how much they might be willing to pay to have the features or the services.

2.3 Summary of Literature Review

This literature review summarizes the evaluation studies that were conducted to measure the benefit and costs of APTS applications. Also, this review investigates hedonic pricing models and contingent valuation methods that could be useful in the economic assessment of the SLO Transit EDAPTS ITS system. It is found from this literature review that very few APTS evaluation studies measured benefits and costs in dollars. The researchers believe this to be due to the lack of effective methods for placing dollar values on benefits that are not easily quantified. Quantifying benefits in dollar values requires creative assumptions and stated preference surveys and this review found that contingent valuation methods, as compared to hedonic pricing methods, show high potential in quantifying the benefits of the SLO Transit EDAPTS ITS system.

3. BENEFIT/COST EVALUATION METHODOLOGIES

This section describes the B/C evaluation methodologies used in the economic assessment of the SLO Transit EDAPTS ITS system. Figure 3.1 shows the evaluation process within the overall analytic framework of this study.

3.1 B/C Ratio Analysis Method

This research project uses the benefit/cost (B/C) ratio as a tool to evaluate the economic justification of the EDAPTS ITS system at SLO Transit. The B/C ratio method has been used extensively in evaluating public works projects since its adoption by the US Army Corps of Engineers under a congressional mandate. This method determines the benefit/cost ratio after the benefits and the costs are quantified and converted to present values or to equivalent annual values. Those projects with B/C ratios greater than 1.0 are economically viable, while those with ratios below 1.0 are not.

This evaluation process is based on the following premise:

> *The EDAPTS technologies (including GPS-based automatic vehicle location (AVL) systems, electronic fare collection (EFC), schedule-adherence displays for drivers, emergency warning devices, and dynamic electronic displays at bus stops giving passengers real-time information about upcoming bus arrivals) improve bus services in several ways. These systems lead to more efficient operations, travel time savings, increased bus patronage, and greater passenger and transit employee satisfaction, most of which can be expressed in terms of specific dollar-quantified benefits to society.*

If these dollar-quantified benefits can be shown to exceed the corresponding costs, this EDAPTS research product can be used to support the economic argument for deploying such EDAPTS ITS technologies in small bus operations. However, even if it turns out that the benefits do not justify the costs or that the benefits of these technologies cannot be adequately dollar-quantified, this is also useful information for bus operators considering the deployment of such technologies and planning to use the benefits verses cost argument as justification for such improvements.

The B/C ratio analysis method involves a systematic process of calculating and comparing benefits and costs characterizing the test deployment of the SLO Transit EDAPTS system. The objective of applying this evaluation technique is to determine if the investment in the test deployment is economically sound. Typically, benefits and costs are discounted over time and compared. The fundamental test of feasibility is for total benefits to outweigh total costs. The equation, as described at the web site of the Caltrans Office of Transportation Economics (*http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/)* is as follows:

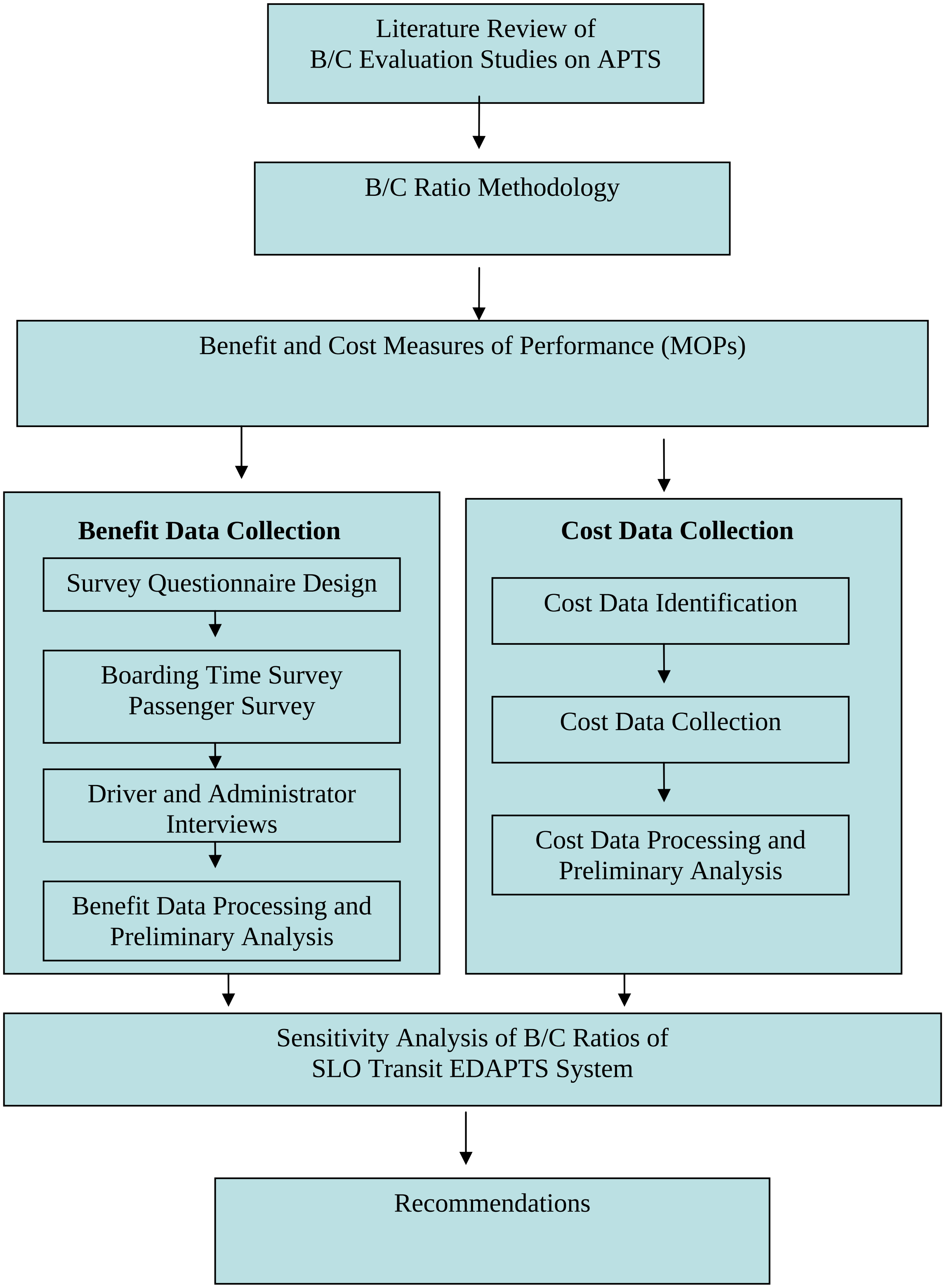

Figure 3-1 Benefit/Cost Evaluation Process for SLO's EDAPTS ITS System

$$B/C\ Ratio = \frac{\sum_{i=1}^{n} \frac{B_i}{(1+d)^i}}{\sum_{i=1}^{n} \frac{C_i}{(1+d)^i}}$$

Where

n - Number of years over which benefits and costs are analyzed
B_i - Benefits of a transportation project in year i, i = 0 to n
C_i - Costs of a transportation project in year i, i = 0 to n
d - Discount rate

The general procedure of the B/C ratio analysis for a transportation project (including the SLO Transit EDAPT System Test Deployment project) is as follows:

Step 1: Determine the service life of the project and the discount rate applicable to the project.

Step 2: Identify, measure, and quantify the benefits of the project and discount them to present or annualized values.

Step 3: Identify, measure, and quantify the costs of the project and discount them to present or annualized values.

Step 4: Sum both the discounted benefits and the discounted costs over the service life of the project and divide the sum of the discounted benefits by the sum of the discounted costs to get the B/C ratio. Equivalently, the B/C ratio can be calculated by dividing the annualized benefits by costs.

The B/C ratio analysis method used in this evaluation used the annualized approach. Annual user benefits were derived for current conditions from surveys of riders, drivers, and SLO Transit managers. Total capital costs were annualized and added to annual operating and maintenance costs in current dollars. Annual benefits were compared with annualized costs to calculate the benefit to cost ratios. This was done for a range of discount rates and service lives that were assumed for annualizing project capital costs.

3.2 Discount Rates

One of the most critical tasks in a B/C ratio analysis is to determine a reasonable discount rate. A proper discount rate permits the values of costs and benefits to reflect the time value of money. All future benefits and costs should be discounted or present costs properly annualized. The higher the discount rate, the greater the impact of near-term cash flows in relation to future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the B/C ratio.

This research adopted the discount rate policy published by the US Office of Management and Budget (OMB) Circular A-94[1] for benefit/cost analyses of public investment and federal programs that provide benefits and costs to the general public:

> *In general, public investments and regulations displace both private investment and consumption. To account for this displacement and to promote efficient investment and regulatory policies, the following guidance should be observed.*
>
> 1. ***Base-Case Analysis**. Constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. Significant changes in this rate will be reflected in future updates of this Circular.*
>
> 2. ***Other Discount Rates**. Analyses should show the sensitivity of the discounted net present value and other outcomes to variations in the discount rate. The importance of these alternative calculations will depend on the specific economic characteristics of the program under analysis. For example, in analyzing a regulatory proposal whose main cost is to reduce business investment, net present value should also be calculated using a higher discount rate than 7 percent.*

The project uses three discount rates of 5%, 7%, and 10% to discount the total benefits and costs for the SLO Transit EDAPTS System. The 7% rate is that recommended by OMB, 5% is the typical bond interest rate (see Section 10.5), and 10% is an arbitrary high value set to twice the typical bond rate.

3.3 Service Life of the SLO Transit EDAPTS System

Service life of the SLO Transit EDAPTS system is an important factor that should be considered in the B/C ratio analysis. Service life is also called the life-cycle benefit and cost horizon or the system economic lifetime. It ends when the system is physically terminated or is replaced by a system with greater economic justification. Some of the factors to determine the service life of the SLO Transit EDAPTS System are the speed of hardware and software changes, the probability of major changes in system requirements, and the estimated costs of maintaining the system.

[1] OMB Circular A-94 is located at http://www.whitehouse.gov/omb/circulars/a094/a094.html#8

The project uses three possible service lives (5-year, 7-year, and 10-year) to discount the total benefits and costs for the evaluation of the SLO Transit EDAPTS system.

3.4 Stated Preference Survey Methods for Intangible Benefit Quantification

This research implements stated preference survey methods in the B/C evaluation of the SLO Transit EDAPTS system. Based on our literature review, we believe very few APTS evaluation studies attempted to measure most benefits and costs in dollars. This is caused by the lack of effective methods for placing dollar values on benefits that are not easily quantified. Quantifying benefits using dollar values requires creative assumptions and stated preference surveys to which contingent valuation methods may be applied in quantifying the benefits of the EDAPTS system. This research is considered to be the first case study to quantify the intangible benefits of APTS applications using stated preference survey methods.

It should be noted that the benefits that are typically quantified in a transportation B/C evaluation project are user benefits like travel time saved, accident reduction, vehicle operation cost reduction, and reduction of environmental impacts such as emissions. Unfortunately, the existing EDAPTS system is unlikely to create many of these conventional benefits. Therefore, in addition to travel time benefits, which were able to be measured, this research project also focused on measuring the benefits related to 1) improved service reliability, 2) improved driver and management effectiveness and morale, 3) improved potential response to incidents such as bus breakdowns, 4) improved customer satisfaction, and 5) improved public image for the transit operator. Because these benefits are intangible and cannot be easily measured using conventional evaluation methods, we choose the stated preference survey methodology to help us assign appropriate values.

Using the stated preference survey method, this project developed a set of survey questions such as “How much would you be willing to pay for …?” to determine the dollar values of intangible benefits. For example, in order to assess the intangible benefit of having electronic real-time bus arrival time displays in the SLO Transit EDAPTS system, we used the following question:

> *Imagine that budget cutbacks force the city to replace all of its existing electronic bus arrival time displays with devices that provide the same information for a fee. How much would you have been willing to pay for reliable bus arrival time information for the trip you are presently taking? (Note that such a change is not being considered. This question is to estimate the value of the information provided by the displays.)*

- *Not willing to pay anything*
- *$0.50*
- *$1.00*
- *$2.00*
- *$3.00*
- *$4.00*
- *$5.00*
- *$6.00*
- *Other (please specify) $_______*

A total of 856 responses to this question were obtained from the interviews with SLO Transit passengers. Analyzing these responses, we estimated that passengers were willing to pay $0.25 for reliable bus arrival time information for their trips. In other way, the average value of dynamic sign showing the real-time bus information is $0.25 per ride (or per boarding). This amount was used as the benefit to riders of having access to the electronic display, counted only for trips boarding at bus stops equipped with the displays.

Using Table 19 of National Transit Databases (NTD), 2005 (http://www.ntdprogram.gov/ntdprogram/data.htm), we estimated the total boardings (or unlinked passenger trips) on SLO Transit buses to be 875,354 in 2005. We also estimated from the passenger surveys that 45% of passengers boarded at stops equipped with real-time bus arrival time displays. Therefore a total of 875,354 * 45% = 393,909 passengers received the services of real-time displays per year. The total estimated benefits of real-time bus arrival information is therefore 393,909 * $0.25 = $98,477 per year. In summary, we had:

Average dollar value of dynamic signs:	$0.25 (from passenger surveys, Table 5.1-10)
Total boardings on SLO Transit buses:	875,354 (from NDT, 2005)
Total boardings with bus arrival time displays:	393,909/year
Total benefits provided by bus arrival time displays:	$98,477/year

It should be noted that we assume that future boardings remain the same as those in 2005 and do not change from year to year within the service life of the SLO Transit EDAPTS system. This probably results in an underestimation of future benefits.

The principle of *willingness-to-pay* provides an aggregate measure of what surveyed passengers are willing to forego to obtain a given benefit or ITS service. Willingness-to-pay is generally regarded as providing a reasonable method for quantifying intangible benefits.

This project collected a variety of intangible benefit data through interviews with personnel of SLO Transit and surveys of transit passengers. The intangible benefits to riders, transit managers, transit staff, and the Cal Poly SLO Parking and Commuter services were evaluated in terms of the following EDAPTS system features:

- On-board emergency management
- Electronic boarding validation and counts of Cal Poly students and staff
- Dispatch management of vehicles through the EDAPTS console

- Vehicle on-time performance as applied to route analysis, planning, and scheduling
- Passenger knowledge of vehicle arrival times through the Smart Transit Signs
- Web map for public use

3.5 Conventional Survey Methods for Tangible Benefit Quantification

To quantify tangible benefits, this project also used conventional survey methodology to evaluate tangible benefits. For example, the project developed a laptop PC or Personal Digital Assistant (PDA)-based program that was used in collecting data on boarding times of riders using different payment media.

The project used this PC/PDA program to measure the boarding times of passengers on SLO Transit buses where the EDAPTS equipment is installed. Boarding times for passengers with Cal Poly ID Cards ("CPCards") who pay fares using EDAPTS' card-swipe equipment were compared to boarding times for passengers who use other fare payment media. It is shown in Section 5.2 that the average boarding time on SLO Transit buses is 2.9 seconds per boarding less than would be the case if the EDAPTS card-swipe system were not present.

The reduction in boarding times due to EDAPTS results in reduced bus travel times throughout the system, which creates user benefits. It is assumed that, in the long term, EDAPTS enables bus schedules along all routes to be a little bit faster than would otherwise be the case because passengers board more quickly. This translates into somewhat faster bus trips and user benefits from travel time savings.

The quantification of benefits that accrue to passengers from reduced bus travel times was carried out as follows:

1) Boarding and alighting locations of trips were obtained from the on-board survey of SLO Transit bus passengers. Once the data were coded and cleaned of apparent errors, a total of 631 reliable trips were available showing origin and destination bus stop locations.

2) For each trip, a matching process was used to determine the most likely bus route or combination of routes used. In most cases, it was assumed that the traveler used the bus route that provided the shortest travel time between the boarding and alighting locations. For the 24 itineraries that required transfers (3.8% of the total), the most likely transfer location was determined manually, and the combination of bus routes that minimized total travel time through that transfer location was assumed to be the one used.

3) Total boarding counts at stops along bus routes (called "passenger loading diagrams") were not obtained in the present investigation. However, during the precursor study in spring of 2000 and 2001, SLO Transit bus routes were surveyed on the order of 6-8 times to develop typical loading diagrams. These data were examined to establish the typical maximum number of people boarding at each stop, on each bus route, on the grounds that the maximum boarding counts and delays would be those that determine the published bus schedules.

4) The travel time savings for each of the 631 reported trips was calculated by counting the number of other people boarding the bus under maximum load conditions at all intermediate stops along the bus route between each passenger's boarding and alighting stops. Note that since the boarding data were from 2000/2001, those counts are probably somewhat less than the number who board the buses in 2007, and therefore leads to a conservative estimate of benefits. The total count of people boarding along each passenger's route was multiplied by 2.9 seconds, the average boarding time reduction per passenger due to EDAPTS, in order to obtain the estimated travel time savings for each passenger's reported trip.

5) The average travel time savings per trip was then estimated for all 631 passengers in the sample, and multiplied by the annual number of SLO Transit bus trips to estimate the total annual travel time saved. That, in turn, was multiplied by the estimated value of time of \$4.56 per hour, obtained from the passenger survey, to obtain the corresponding annual user benefits.

The actual user benefit calculation appears in Section 5.5.

In following the above procedure, it was found that the travel time saved by individual surveyed passengers ranged from zero to just over 180 seconds (3 minutes). The histogram in Figure 3.5-1 shows the distribution of individuals' travel time savings due to faster boarding by everyone who boarded the bus while that person was en-route, assumed to be reflected in the published bus schedule. It can be seen in the figure that the savings are pretty small, less than 15 seconds per trip, for about 230 travelers, somewhat over a third of the 631 passengers represented in the survey. Since tiny travel time savings can be argued to have negligible economic value, it was decided to calculate the average trip time saved by including only trips for which the individual trip time savings were at least 30 seconds. When this is done, the average trip time saved by all travelers in the survey came to 40 seconds per trip. That is the value used in the benefit calculation described previously. (Note that if time savings less than 30 seconds are also included, the average trip time saving is 45.8 seconds, so this adjustment does not really make a large difference.)

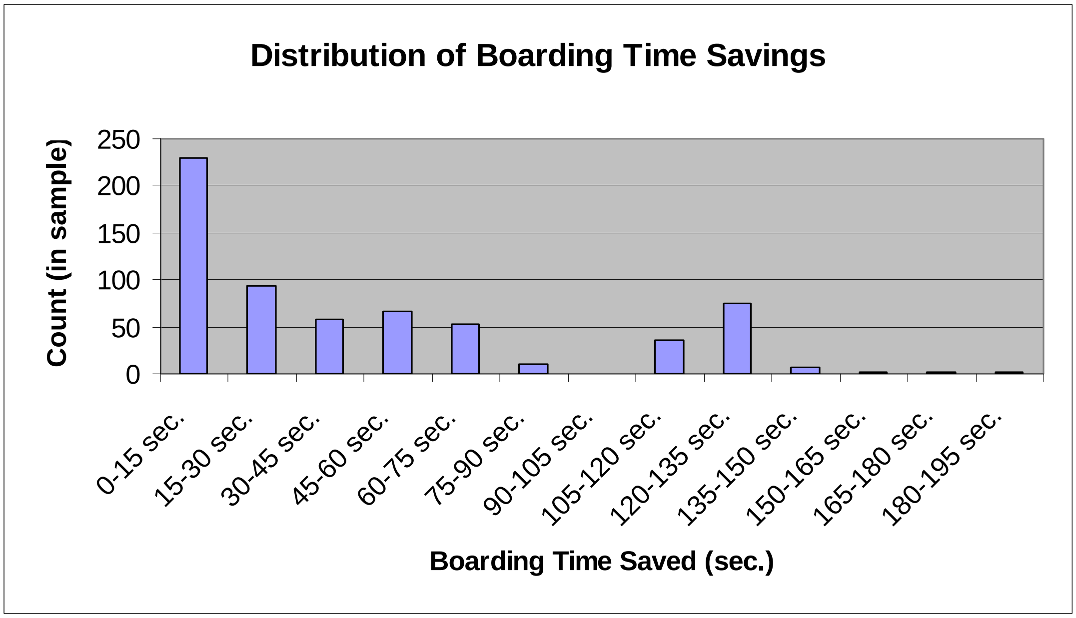

Figure 3.5-1 Distribution of Passengers' Travel Time Savings Due to Faster Boarding

3.6 B/C Ratios and Sensitivity Analysis

The project considered all of the available data on costs and benefits and performed a benefit/cost evaluation following the standard procedure for determining the economic feasibility of transportation projects. We calculated B/C ratios using different discount rates and assumed service lives for the SLO Transit EDAPTS System. The calculated B/C ratios were used to assess the economic merits of the San Luis Obispo EDAPTS deployment.

It should be noted that the benefit and cost quantities underlying this economic assessment are specific to conditions at SLO Transit, and would certainly be different at other locations. In particular, several benefit categories are influenced by the high proportion of university affiliated riders who board using campus IDs, and by the dominance within the travel patterns of a few bus stops that are equipped with EDAPTS displays. Nevertheless, although our results are specific to this setting, the higher the B/C ratios obtained the more likely it is that benefits generated at other deployment locations would also exceed the costs, resulting in economic justification for other deployments as well.

Sensitivity analysis is required by the US Office of the Management and Budget OMB to test the robustness of the B/C ratios calculated for public investments and projects with Federal funds. Since the B/C ratio is the key indicator in this evaluation of the EDAPTS ITS project, transit agencies considering the adoption of EDAPTS technologies would also want assurance that the analysis is robust. Sensitivity analysis varies input parameters that influence the B/C ratio. If a relatively small change in the input parameter changes the outcome, then the analysis is considered to be sensitive to that parameter. The estimates for sensitive input parameters should then be re-examined to ensure that they are as accurate as possible.

This study examined the sensitivity of the B/C ratio for varying service lives of the EDAPTS components and different discount rates. In general, components with longer service lives and higher discount rates may have lower annualized capital costs and thus higher B/C ratios. The more the B/C ratio exceeds one, the more viable is the project as an investment option.

4. BENEFIT AND COST MEASURES OF PERFORMANCE (MOPS)

One of the most critical tasks in a B/C analysis is to identify measure and quantify benefits and costs. This project identified a fairly large set of benefit and cost measures of performance (MOPs) pertaining to the SLO Transit EDAPTS system. This was accomplished through a process of brain-storming and discussions of the features of EDAPTS.

The benefit measures considered for this research consist of both tangible and intangible measures. They reflect the perspectives of riders, drivers, dispatchers, system managers, and the community at large. Most fall into three general categories: 1) measures of benefits that accrue to passengers riding the SLO Transit buses, 2) measures of benefits that accrue to SLO Transit's operator/owner, and 3) measures of benefits that accrue to SLO Transit bus drivers. In addition, benefits such as those arising from reduced parking demand in the community were considered.

The cost measures were the obvious, consisting of measures that quantify capital, operational and maintenance costs related to the installation and operation of the SLO EDAPTS system.

The product of this effort is an MOP matrix that lists all the cost and benefit measures used in the benefit/cost evaluation.

4.1 Benefit MOPS

Table 4.1-1 shows the benefit measures of performance. It also identifies the beneficiaries and a brief description of how the benefit would be measured. Benefit MOPs listed in Table 4.1-1 consist of benefits to passengers, SLO Transit, drivers, and the community.

Benefits to Passengers

The SLO Transit EDAPTS system, that uses the Automatic Vehicle Location (AVL) technologies, provides many benefits to passengers. These benefits include

- Value of reduced response time from GPS data in the event of a bus breakdown
- Value to passengers of knowing arrival times so that passengers experience reduced stress, improved certainty regarding bus services, and easier planning of trip activities
- Value of more reliable trip times from improved schedule adherence and coordination (SLO-to-SLO and SLO-to-RTA[2])
- Benefit from increased trip making induced by faster and more reliable performance
- Value of reduced trip times due to faster boarding operations (due to card-swipe technology)

[2] RTA – San Luis Obispo Regional Transit Authority

Table 4.1-1 Benefit Measures of Performance Considered

	Benefit Measures of Performance (MOPs)	Benefits to Whom?	How to Measure
1	Running time savings from electronic fare collection	SLO Transit	Measure boarding time w/ & w/o EDAPTS, accumulate to running time and value of reduced operating expenses
2	Administrative cost reduction from less cash handling and accounting/reporting for fares	SLO Transit	Administrative costs of fare handling w/ and w/o system
3	Value to drivers in reduced stress, ability to stay on schedule and allow passengers to make transfers	Drivers	Contingent value of perceived benefit, measured by survey
4	Value to drivers in reduced stress, ability to stay on schedule and allow passengers to make transfers	SLO Transit	Labor cost reduction due to reduced employee turnover, reduced absenteeism, etc. (survey)
5	Value to drivers of panic button, ability to summon help quickly in an emergency	Drivers	Contingent value of perceived benefit, measured by survey
6	Value to SLO Transit of panic button, ability to summon help quickly in an emergency	SLO Transit	Contingent value of perceived benefit, measured by survey
7	Impact of GPS in monitoring driver job performance and supervision	SLO Transit	Labor cost reduction from improved discipline
8	Value of reduced response time from GPS data in the event of a bus breakdown	Passengers	Response time w/ and w/o EDAPTS and apply saving to passengers' value of time
9	Value of reduced response time from GPS data in the event of a bus breakdown	SLO Transit	Value of reduction in driver's lost time before returning to productive work

Table 4.1-1 Benefit Measures of Performance Considered (Cont'd)

	Benefit Measures of Performance (MOPs)	Benefits to Whom?	How to Measure
10	Value to passengers of knowing arrival times (reduced stress, improved certainty, activity planning for regular passengers)	Passengers	Contingent value of perceived benefit, measured by survey
11	Value to passengers of knowing arrival times (reduced stress, improved certainty, activity planning for occasional passengers (rainy days, special events, etc.))	Passengers	Contingent value of perceived benefit, measured by survey
12	Value of reduced trip times from improved schedule coordination and reliability (SLO-to-SLO and SLO-to-RTA)	Passengers	Value of trip time saved
13	Avoidance of service contract penalties (if exist) due to improved on-time performance (probably a transfer payment rather than a true benefit)	Contractor	Change in contract penalties w/ and w/o EDAPTS
14	Benefit from increased ridership from having traveler information	Passengers	Contingent value of perceived benefit, measured by survey (value of trip minus fare paid)
15	Benefit from increased ridership from having traveler information	SLO Transit	Increased Revenue ($/rider)
16	Benefit from increased ridership due to more reliable performance	Passengers	Contingent value of perceived benefit, measured by survey (value of trip minus fare paid)

Table 4.1-1 Benefit Measures of Performance Considered (Cont'd)

	Benefit Measures of Performance (MOPs)	Benefits to Whom?	How to Measure
17	Benefit from increased ridership due to more reliable performance	SLO Transit	Increased Revenue ($/rider)
18	Indirect benefit to university and community due to increased ridership (less parking needed)	Community	Avoidance of cost of new parking construction($/space)
19	Value of real-time operational data in improved dispatch operations, short term system efficiency	SLO Transit	Savings in cost of collecting operational data (ridership profile, travel time, etc)
20	Value of reduced trip times (especially wait time, missed transfers)	Passengers	Value of out-of-vehicle time by trip purpose
21	Value of reduced vehicle operating & maintenance costs	SLO Transit	Ask SLO transit
22	Value of accident reduction due to schedule control and no need for aggressive driving to return to schedule	SLO Transit	Ask SLO transit
23	Value of emission reduction due to schedule control and no need for aggressive driving to return to schedule	Community	Ask SLO transit
24	Value of reduced complaints about service	SLO Transit	Reduced complaints w/ & w/o EDAPTS ($ associated with staff time)
25	Value of civic pride and satisfaction in having a progressive, well run transit system	SLO Transit	Contingent value of perceived benefit, measured by survey

Benefits to SLO Transit

The SLO Transit EDAPTS system, that uses the Automatic Vehicle Location (AVL) technologies, provides many benefits to SLO Transit. These benefits include

- Administrative cost reduction from less cash handling and accounting/reporting for fares
- Value to SLO Transit of ability to stay on schedule and allow passengers to make transfers
- Value to SLO Transit of panic button, ability to summon help quickly in an emergency
- Impact of GPS in monitoring driver job performance and supervision
- Value of reduced response time from GPS data in the event of a bus breakdown
- Benefit of increased revenue from having traveler information and reliable performance
- Running time savings from electronic fare collection
- Value of real-time operational data in improved dispatch operations and system efficiency
- Value of reduced vehicle operating & maintenance costs
- Value of accident reduction due to schedule control and no need for aggressive driving to return to schedule
- Value of reduced complaints about service

Benefits to Drivers

The SLO Transit EDAPTS system, that uses the Automatic Vehicle Location (AVL) technologies, provides benefits to drivers that include

- Value to drivers in reduced stress from ability to more easily stay on schedule and allow passengers to make transfers
- Value to drivers of panic button, ability to summon help quickly in an emergency
- Avoidance of penalties (if exist) due to improved on-time performance

Other Community Benefits

- Indirect benefit to university and community due to increased ridership (less parking needed)
- Value of emission reduction due to schedule control and no need for aggressive driving to return to schedule
- Value of civic pride and satisfaction in having a progressive, well run transit system

4.2 Cost MOPS

Table 4.2-1 shows the cost measures of performance and a brief description of how each would be measured. Because the EDAPTS implementation for SLO Transit was a pilot demonstration project, many of the listed costs were covered by the project, although under normal conditions all of these costs would fall upon the transit operator. It should be noted that all annual maintenance costs listed in the table incorporate occasional replacement due to failures, accidents or vandalism. Costs of power for operating on-board units and computers are ignored.

Cost MOPs listed in Table 4.2-1 include capital costs, operation and training costs, and maintenance costs.

Capital Costs

In order to install the SLO Transit EDAPTS system, the following capital costs were incurred:

- On-board units – Manufacture
- On-board units – Installation
- Street-side displays – Manufacture
- Street-side displays – Installation
- System control, data acquisition console
- Operator consoles (dispatch)

Table 4.2-1 Cost Measures of Performance Considered

	Cost Measures of Performance (MOPs)	**How to Measure**
1	Capital Cost - On-board units - Fabrication	Material cost and cost of assembly time per unit (Issue: does unit cost vary enough with quantity to quantify the variation?)
2	Capital Cost - On-board units - Installation	Cost of installation time & materials per unit (Issue: does unit cost vary enough with quantity to quantify the variation?)
3	Capital Cost - Street-side displays – Fabrication	Material cost and cost of assembly time per unit (Issue: does unit cost vary enough with quantity to quantify the variation?)
4	Capital Cost - Street-side displays – Installation	Cost of installation time & materials per unit (Issue: does unit cost vary enough with quantity to quantify the variation?)
5	Capital Cost - System control, data acquisition console	Cost of computer and telecommunications equipment acquisition and installation
6	Capital Cost - Operator consoles (dispatch)	Cost of computer and telecommunications equipment acquisition and installation per unit
7	Front-end System Setup, Calibration	Hours for system setup x average rate of systems engineer/tech.
8	Initial driver training in EDAPTS operation	Hours of initial training per driver x burdened average driver hourly rate x # of drivers + Hours of training x # sessions x trainer(s) hourly rate
9	Continuing driver training in EDAPTS operation	# new driver hires/year x hours of training per driver x [burdened average driver hourly rate + burdened average trainer hourly rate] {assumed one-on-one training for new hires}

Table 4.2-1 Cost Measures of Performance Considered (Cont'd)

	Cost Measures of Performance (MOPs)	How to Measure
10	Initial office personnel training in EDAPTS operation	Hours of initial training per person x burdened average hourly rate x # of people + Hours of training x # sessions x trainer(s) hourly rate
11	Continuing training of office personnel	# new people hired/year x hours of training per person x [burdened average hourly rate + burdened average trainer hourly rate] {assumed one-on-one training for new hires}
12	System operating costs	Annual communication fee per street-side display x # of displays + Annual communication fee per bus x # of buses + Annual web-hosting account fee + Hours per nightly data archiving * Wage Rate * 365 Days per Year + Hours per monthly reporting * Wage Rate * 12 months/year
13	On-board unit maintenance	Average annual maintenance cost per bus (time and materials) x # of buses
14	Street-side display maintenance	Average annual maintenance cost per display (time and materials) x # of displays
15	Maintenance of system control and dispatch consoles	Average annual hours of system maintenance x average rate of systems engineer/tech.
16	Setup and recalibration for bus system changes (quarterly)	Average annual hours of system maintenance x average rate of systems engineer/tech.

Operation and Training Costs

In order to install the SLO Transit EDAPTS system, the following operation and training costs were incurred:

- System operating costs
- Front-end system setup, calibration
- Initial driver training in EDAPTS operation
- Continuing driver training in EDAPTS operation
- Initial office personnel training in EDAPTS operation
- Continuing training of office personnel

Maintenance Costs

In order to operate the SLO Transit EDAPTS system, the following maintenance costs are incurred:

- Setup and recalibration for bus system changes (quarterly)
- On-board unit maintenance
- Street-side display maintenance
- Maintenance of system control and dispatch consoles

5. BENEFIT DATA COLLECTION

The study team used a variety of primary data collection methods to gather the data regarding benefit measures that are identified in Section 4. Four distinct data-gathering tasks were completed to collect benefit information:

- An on-board self-administered survey of passengers to measure how passengers' travel behaviors may have changed due to improvements to bus services enabled by the EDAPTS ITS technologies, and how much value, in dollar terms, passengers attribute to these travel changes and to the improved bus services generally.

- On-board observations to measure passenger boarding-times on buses with and without EDAPTS ITS technologies.

- Structured interviews with bus drivers

- Structured interviews with SLO Transit administrators

These data-collection methods are described in the following sections. The description in each section is followed by a summary of the data collected.

5.1 Passenger Survey

The project administered a self-administered passenger survey on the SLO Transit System. It involved tasks including 1) Passenger Questionnaire Design, 2) Administration of the Survey, and 3) Preliminary Analysis of Passenger Survey Data.

Passenger Questionnaire Design

Relying heavily on the stated preference survey method described in Section 3, a self-administered questionnaire was constructed with questions to elicit information related to the various benefit items identified in Section 4. The design of the questionnaire considered the fact that participation in the survey was voluntary and anonymous.

Because the survey involved human subjects, the research team submitted the questionnaire and the survey plan for approval by the Human Subjects Committees of Cal Poly San Luis Obispo, Cal Poly Pomona, and California PATH. The Human Subject Committees evaluated the questionnaire in terms of its compliance with ethical standards regarding the treatment of human subjects. The Committee reviews provided objective input as an additional protection for the human subjects involved in this research.

Pilot testing was conducted on the questionnaire survey after the survey plan and survey questions were approved. Based on the pilot test results, we slightly revised the survey questionnaire. The final questionnaire was printed on a convenient size card stock, which also contained a postage-paid return mailer. The questionnaire is shown in Figure 5.1-1.

4. Do you consider the amount of time that you had to wait for the bus to be. . .

- [ ] Acceptable?
- [ ] Too long?

5. On average, how often do you ride the bus?

- [ ] >5 times a week
- [ ] 3-5 times a week
- [ ] 1-2 times a week
- [ ] 1-3 times a month
- [ ] Less than once a month

6. In your experience, how often do the buses on this route run on time?

- [ ] Always or almost always
- [ ] Most of the time
- [ ] Sometimes (a quarter to three-quarters of the time)
- [ ] Rarely
- [ ] No opinion or don't know.

7. Imagine that the bus route you are now riding operates at least 10 min. late more than a quarter of the time. If this were the case, would it cause you to ride this bus route less often?

- [ ] It would not change anything
- [ ] I would make some fewer trips (less than a quarter of present bus trips)
- [ ] I would make many fewer trips (a quarter to half of present trips)
- [ ] I would stop making most trips on this route (more than half of present trips)
- [ ] I'd stop riding the bus altogether
- [ ] I don't know

8. Do you know that SLO buses have a GPS vehicle location system (that tracks where the buses are at all times)?

- [ ] Yes
- [ ] No

9. How many of your typical bus trips either begin or end at bus stops equipped with electronic bus arrival time displays?

- [ ] Most of them (more than half)
- [ ] Many of them (between a quarter and a half)
- [ ] Some of them (less than one in four)
- [ ] None or don't know

10. What is your opinion of the bus arrival time displays located at major bus stops?

- [ ] Very accurate when turned on
- [ ] Fairly accurate when turned on
- [ ] Not accurate
- [ ] No opinion

11a. Does the availability of the electronic bus arrival time display at major bus stops cause you to use the bus more often?

- [ ] Yes
- [ ] No
- [ ] I don't know

11b. If you answered "Yes," how many of your present bus trips would you probably not make if there were no electronic bus arrival time displays anywhere in town?

- [ ] Some (less than a quarter of my present bus trips)
- [ ] Many (between a quarter and half of my present bus trips)
- [ ] Most (more than half my present bus trips)
- [ ] I'd stop riding the bus altogether
- [ ] I don't know

12. Imagine that soon after you boarded this bus the driver announced that the bus will get to your destination 10 minutes behind schedule. However, a special taxi-shuttle is available that will get you to your destination on time. What's the most you would be willing to pay to get a space on this special shuttle? (Note: this isn't going to happen. This question is to estimate your value of time.)

- [ ] Not willing to pay anything
- [ ] $0.50
- [ ] $1.00
- [ ] $2.00
- [ ] $3.00
- [ ] $4.00
- [ ] $5.00
- [ ] $6.00
- [ ] Other (please specify) $ ____________

13a. Now imagine that just before starting your present trip, you learned that the bus service shut down due to a sudden strike. However, a limited capacity taxi-shuttle is available that will get you to your destination at least as fast as the bus. What's the most you would be willing to pay to guarantee yourself a space on this taxi-shuttle? (Note: this isn't expected to happen either. This question is to estimate the importance of trips being made.)

- [ ] Not willing to pay anything
- [ ] $0.50
- [ ] $1.00
- [ ] $2.00
- [ ] $3.00
- [ ] $4.00
- [ ] $5.00
- [ ] $6.00
- [ ] Other (please specify) $ ____________

13b. In the situation described above, if neither the bus service nor the pretend taxi-shuttle were available, how would you get to your present destination?

- [ ] Walk or bike
- [ ] Drive
- [ ] Ask a friend or family member for a ride
- [ ] I wouldn't make this trip if the bus wasn't available
- [ ] Other (describe): ____________

14. Finally, imagine that budget cutbacks force the city to replace all of its existing electronic bus arrival time displays with devices that provide the same information for a fee. How much would you have been willing to pay for reliable bus arrival time information for the trip you are presently taking? (Note that such a change is not being considered. This question is to estimate the value of the information provided by the displays.)

- [ ] Not willing to pay anything
- [ ] $0.50
- [ ] $1.00
- [ ] $2.00
- [ ] $3.00
- [ ] $4.00
- [ ] $5.00
- [ ] $6.00
- [ ] Other (please specify) $ ____________

15. Do you have access to a car that you could have used for the bus trip you are making today?

- [ ] Yes
- [ ] No

16. Your gender:

- [ ] Male
- [ ] Female

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Figure 5.1-1(a) Passenger Questionnaire Survey Form (Front Side)

17. Are you:

- ☐ A student or trainee in the SLO area
- ☐ Employed full-time in the SLO area
- ☐ Employed part-time in the SLO area
- ☐ Other resident of the SLO area
- ☐ Temporarily visiting the SLO area from elsewhere
- ☐ Other: ____________________

18. Your age group:

- ☐ Under 16
- ☐ 16-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 66-75
- ☐ Over 75

Thank you for your help. Do you have any comments or suggestions regarding local transit services?

____

____

____

____

- - - - - - - - - - Fold here if returning by mail - - - - - - - - - -

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San Luis Obispo Transit Passenger Survey (2007)

Please read before completing the survey

Dear Customer:

We ask for your help in a research project to evaluate some new features of the bus services being provided to you. Please take about 15 minutes to fill out this survey. Your participation involves no risk and is entirely optional; any answers you give will be kept anonymous in order to protect your privacy. If you choose to voluntarily participate, please hand your completed survey to the attendant on board the bus or put it in the box located near the rear exit; you may also mail it back postage-free. (Please do NOT give it to the driver.) In some multiple-choice questions, more than one reply may be given. Some questions ask you to judge how you might respond to imaginary situations; although you may find such questions difficult or even peculiar, please do your best to imagine what you might actually do in the situations described.

If you have questions about this research or would like to see the results when completed, please contact Professor Edward Sullivan at 805-756-2131 or esulliva@calpoly.edu. If you have other questions or concerns about the manner in which the survey is being conducted, you may contact Steve Davis, Chair of the Cal Poly Human Subjects Committee, at 756-2754, or Susan Opava, Dean of Research and Graduate Programs, at 756-1508.

I got on this bus at (location): ____________

To exit at (location): ____________

1. How did you get to the bus stop today?

- ☐ I walked for _____ minutes
- ☐ I rode my bike for _____ minutes
- ☐ I drove for _____ minutes
- ☐ I was dropped off; and it took _____ minutes
- ☐ I transferred from another route – Route #: _____
- ☐ Other ____________________

2. How did you know when this bus would leave the bus stop that you used?

- ☐ I have a bus schedule
- ☐ I use this stop often and know the schedule
- ☐ I called the transit system help line to get the time
- ☐ I didn't know. I arrived when it was convenient hoping the bus would arrive soon
- ☐ I checked the transit website on the internet
- ☐ I checked the electronic bus arrival information displayed at the bus stop (if applicable)

3. How long did you wait at the stop today before the bus arrived?

_________ minutes

Figure 5.1-1(b) Passenger Questionnaire Survey Form (Back Side)

Passenger Survey Administration

The on-board self-administered passenger survey was distributed by teams of surveyors riding SLO Transit bus routes. After an adult passenger boarded, the surveyor asked if he or she was willing to participate in a passenger survey and, if so, was handed a questionnaire and golf pencil. A passenger who managed to complete the questionnaire during the bus trip handed it back. Otherwise, it was mailed back later using the included prepaid mailer.

Based on statistical considerations, a target sample size of 400 completed surveys was sought. Assuming a 40% success rate, we attempted to distribute no fewer than 1000 surveys. Due to enthusiasm from riders in the pilot testing and the relatively low total daily ridership, the survey team attempted to sample 100% of riders over the different SLO bus routes, as well as over the hours of the day. All data was obtained on typical good-weather days with Cal Poly SLO in session. Figure 5.1-2 shows passengers reading the questionnaire before they complete the questions.

The questionnaire survey provided 658 valid returns overall and not less than 650 valid responses were found for any question. Under the most conservative assumptions, findings from the returned sample are accurate with an error level of +/-3.8% and a 95% confidence interval.

Figure 5.1-2 Passenger Questionnaire Survey

Preliminary Analysis of Passenger Survey Data

The project conducted a preliminary analysis of the data collected from the survey of SLO Transit passengers. A Visual Basic computer program was developed to assist in the preliminary data analysis of the collected data (see Figure 5.1-3). Using this program, the surveyors entered all the original responses of SLO Transit passengers into the data processing form, saved them into a "|" delimited text file, and then loaded the text file into Microsoft EXCEL for preliminary analysis.

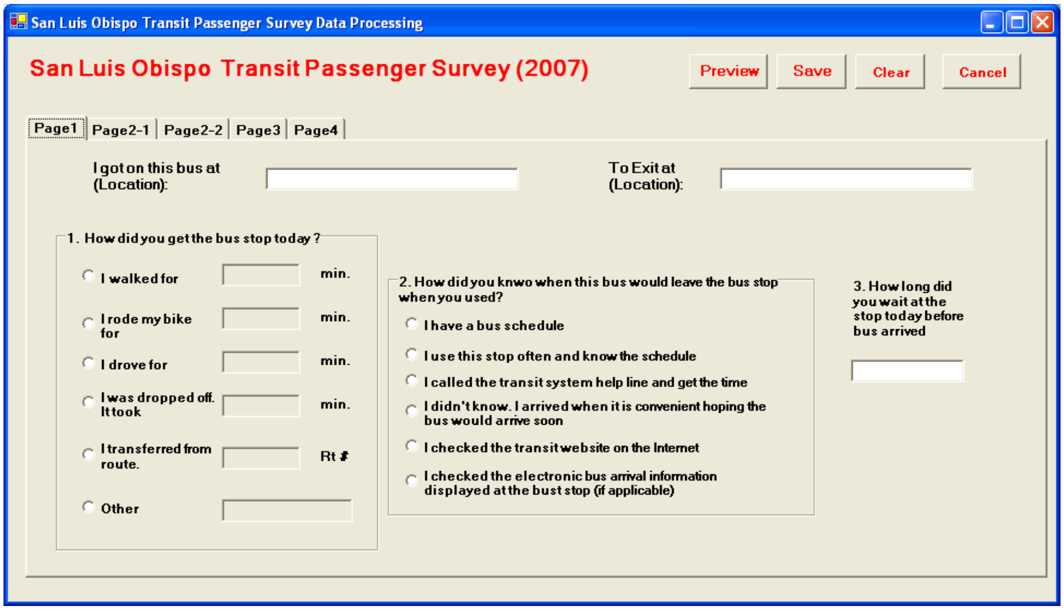

Figure 5.1-3 Questionnaire Data Entry Program

The rest of this section provides a comprehensive summary of the passenger survey data using charts and tables. Most charts provided in this section are based on data in the tables. While charts offer visual illustrations of distributions, tables provide exact data that may be useful to other researchers.

Ingress Mode

Table 5.1-1 and Figure 5.1-4 show the distribution of modes used by SLO Transit riders to access the service. The overwhelming majority (87%) walk to the bus stops. This is followed by those who drive or are dropped off. Survey results indicate that transfers constitute only a small fraction (4%) of rides.

Table 5.1-1 Ingress Mode Distribution

Ingress Mode	Respondents	Percent
Walked	574	87.2%
Drove	34	5.2%
Biked	21	3.2%
Transferred	27	4.1%
Other	2	0.3%
Total	658	100.0%

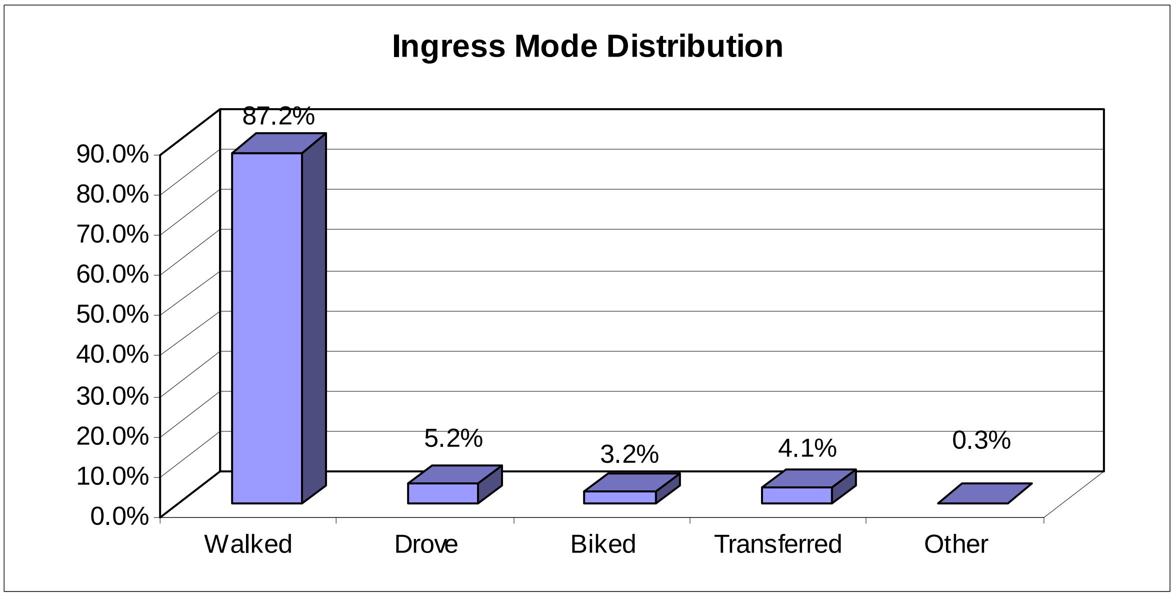

Figure 5.1-4 Ingress Mode Distribution

Ingress Time

Consistent with the dominance of walking to access SLO Transit, most riders travel relatively short periods of time to bus stops. The most common time riders take to access the transit service is between one and five minutes: half of all riders take 3 minutes or less; 82% take 5 minutes or less; and 95% take 10 minutes or less. Table 5.1-2 and Figure 5.1-5 show the distribution of ingress times.

Table 5.1-2 Ingress Time Distribution

Ingress Mode	0 -- 1 Minutes	1.1 – 3 Minutes	3.1 -- 5 Minutes	5.1 -- 10 Minutes	10.1 -- 15 Minutes	15.1 + Minutes	Total
Walked	116	187	173	71	18	8	573
Drove	0	11	12	10	0	1	34
Biked	1	5	11	3	0	1	21
Transferred	1	11	7	4	2	0	25
Other	1	0	0	0	0	0	1
All	119	214	203	88	20	10	654
Percent of Total	18.2%	32.7%	31.0%	13.5%	3.1%	1.5%	100.0%
Cumulative %	18.2%	50.9%	82.0%	95.4%	98.5%	100.0%	

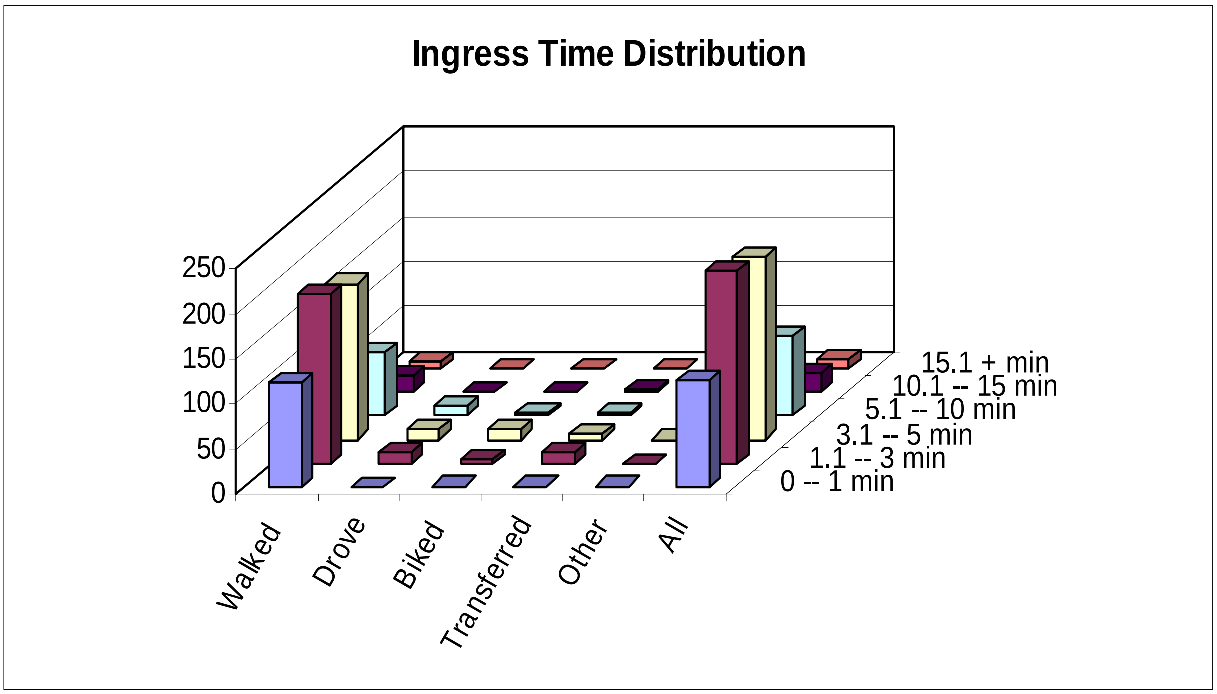

Figure 5.1-5 Ingress Time Distribution

Knowledge of Schedule

Two thirds of SLO Transit passengers are habitual riders and know the scheduled bus times. Another fifth of riders have bus schedules. Table 5.1-3 shows the ways SLO Transit riders obtain information on bus schedules.

Table 5.1-3 Knowledge of Schedule

Schedule-Knowledge	Total	Percent
Called transit system help line	9	1.4%
Checked electronic bus arrival display	4	0.6%
Checked transit website	31	4.7%
Arrived when convenient	28	4.3%
Have a bus schedule	130	19.8%
Use often and know the schedule	455	69.3%
Total	657	100.0%

Wait Time

Figure 5.1-6 shows the distribution of wait times for SLO Transit buses. The average wait time is just over 5 (or 5.17) minutes. Nearly half of all riders take 3 minutes or less; nearly three quarters of riders take 5 minutes or less; and 92% take 10 minutes or less.

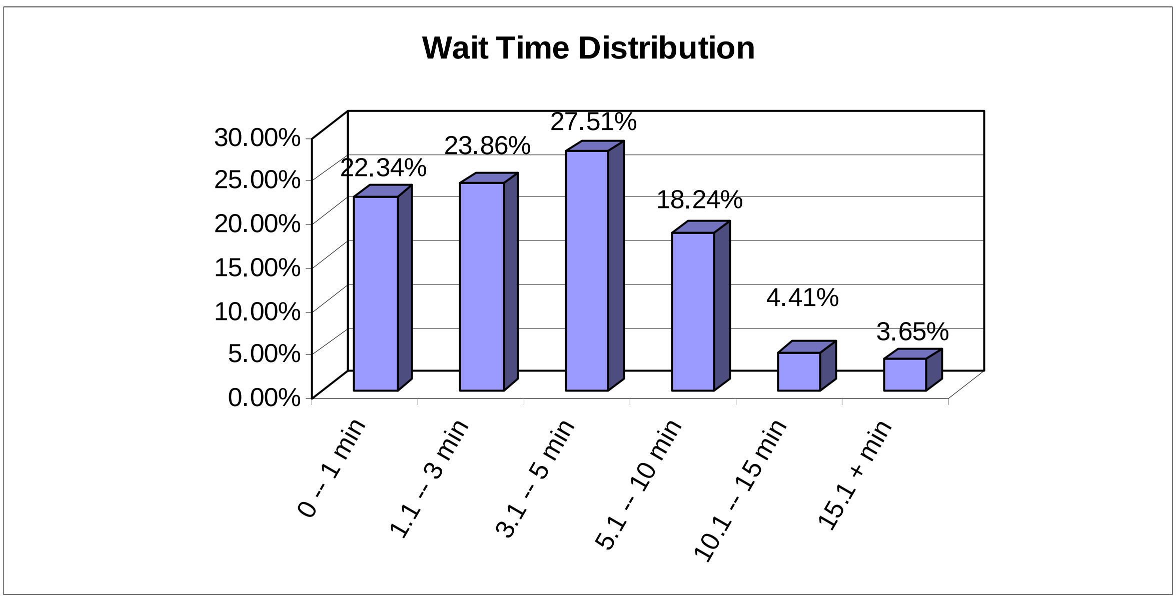

Figure 5.1-6: Wait Time Distribution

Wait Time Acceptability

Consistent with the short wait times reported by SLO Transit riders is the overwhelming agreement that the length of wait time is "acceptable." 94% of respondents agree while 6 % disagree.

Frequency of Service Usage

Consistent with the result that the majority of riders have knowledge of bus schedules, the overwhelming majority (85%) of survey respondents indicate that they are habitual riders. This means they ride at least three times a week. Table 5.1-4 shows the distribution.

Table 5.1-4 Distribution of Ride Frequency

	Frequency of Service Use	**Total**	**Percent**
1	Less than once a month	11	2%
2	1-3 times a month	28	4%
3	1-2 times a week	58	9%
4	3-5 times a week	216	33%
5	> 5 times a week	345	52%
	Total Respondents	658	100%

Service Reliability

SLO Transit riders consider the service reliable in general. While only a quarter of respondents consider service “nearly always” reliable, slightly more than an additional half of respondents considers it reliable “most of the time”. Table 5.1-5 shows the distribution.

Table 5.1-5 Rider Opinion on Service Reliability

	Reliability	**Total**	**Percent**
1	Always or almost always	181	27.5%
2	Most of the time	359	54.6%
3	Sometimes	82	12.5%
4	Rarely	25	3.8%
5	No Opinion or Don't know	11	1.7%
	Total	658	100.0%

Reaction to 10-minute Bus Lateness

This question was asked to try to measure the sensitivity of system ridership to on-time performance. Survey respondents indicate varied levels of discontinuance in patronage if buses should run late by 10 minutes. A relatively small portion, 7%, would discontinue riding altogether while more than a quarter (28%) will continue to make trips at existing levels. Table 5.1-6 shows the distribution. The sum total of cutbacks in trip-making via SLO Transit would amount to a 41% reduction in rides. This has direct implications for the EDAPTS ITS features that enhance on-time performance. Technology that helps improve or maintain reliability could thus help to retain ridership, or increase it in the case where original on-time performance is poor.

Table 5.1-6 Rider Reactions to 10 Minutes Lateness of Buses

	Reaction to 10-minute Lateness	**Total**	**Percent**	***Mid-point***	***Lost Trips***	***Proportion Lost Trips***
1	Make no trips	46	7%	1	46.0	
2	Make < 1/4 of trips	144	22%	0.875	126.0	
3	Make1/4 - 1/2 of trips	114	17%	0.625	71.25	
4	Make > 1/2 of trips	110	17%	0.25	27.5	
5	Make all of trips	183	28%	0	0	
6	I don't know	61	9%			
	Total Respondents	658	100%		270.75	0.41

Awareness of GPS

Global Positioning System (GPS) technology is used to track the locations of SLO Transit buses in real time. It helps dispatchers monitor vehicle locations relative to schedule time points. It also helps customer service verify rider complaints about service reliability. The majority of respondents (70%) were not aware of the presence of the technology. The remaining 30% were aware of it.

Working Displays at Stops

Bus arrival time displays are currently installed at eight major stops in the SLO Transit system including the Downtown Transit Center/Government Center, Mott Gym/Student Union on Cal Poly SLO campus, Foothill behind Albertson's and Ramona. Survey responses indicate that about 45% of passengers board buses at locations with displays. Survey responses suggest, however, that approximately 70% of respondents are aware of and have opinions regarding the working status of the displays. Less than a third (28%) are not aware of the displays and a fifth consider that the displays work more than half of the time. Table 5.1-7 shows the distribution.

Table 5.1-7 Rider Opinions on Working Status of Displays at Bus Stops

	Working Status of Displays	**Respondents**	**Percent**
1	Most of them (more than half)	139	21%
2	Many of them (1/4 - 1/2)	113	17%
3	Some of them (less than 1/4)	219	33%
4	None or don't know	187	28%
	Total Respondents	658	100%

Accuracy of Displays

Consistent with the number of riders not aware of bus arrival time displays is the fact that under a third (31%) of respondents had no opinion on the accuracy of the displays. Only a very small number of respondents (13%) consider the displays "very accurate" when turned on. In all, approximately half of riders think they are somewhat accurate. The other half disagree or had no opinion. Table 5.1-8 shows the distribution.

Table 5.1-8 Rider Opinions on Accuracy of Displays at Bus Stops

	Opinion of Display Accuracy	Total	Percent
1	Very accurate when turned on	86	13%
2	Fairly accurate when turned on	266	40%
3	Not accurate	103	16%
4	No Opinion	202	31%
	Total Respondents	657	100%

Effect of Displays on Rides Taken

Survey responses suggest that the presence of the bus arrival time displays have little effect on riders' decisions to make trips on SLO Transit. Nearly three-fifths of respondents (58%) indicate the displays have no effect. Another quarter of respondents (26%) "do not know" if the display effects their choice to ride. 16% of respondents concur that the displays do have an effect on their decision to ride.

Reaction If No Displays at Stops

Consistent with the fact that only a third of rides originated at stops with bus arrival time displays is the fact that two-thirds of those surveyed gave no response to the question on what they would do if there were no displays at the stops. Another fifth of respondents do not know how they will react. In all, only 14% of respondents indicate some level of reaction indicating an 8.4% reduction in rides overall if there were no displays. No matter how small, this indicates some benefit in terms of ridership retention or gain with the presence of the displays. Table 5.1-9 shows the distribution.

Table 5.1-9 Rider Reactions to Absence of Displays at Bus Stops

	Reaction if no Display	**Total**	**Percent**	***Mid-Point***	***Lost Riders***	***Proportion of Lost Trips***
1	I don't know	123	18.7%			
2	I'd stop riding	2	0.3%	1.00	2.0	
3	Stop most (>1/2 of trips)	59	9.0%	0.75	44.25	
4	Stop many (1/4 -1/2 of trips)	20	3.0%	0.375	7.5	
5	Stop some (<1/4 of trips)	12	1.8%	0.125	1.5	
6	No Response	442	67.2%			
	Total Responses	658	100.0%		55.25	0.084

Willingness to Pay for Arrival Information

The majority of survey respondents (80%) are not willing to pay anything to have the bus arrival time display information. Depending on riders' financial situation and trip purpose, it is expected that those willing will pay evaluated the bus arrival information differently. Table 5.1-10 shows the distribution. The modal amount dollars riders are willing to pay is $1. The average amount they are willing to pay is $0.25. Note that there are a few passengers, who claimed in the survey that they are willing to pay a substantial fee for the information, which some might think difficult to believe. If the $6 and $5 observations are eliminated as possibly suspect, the average willingness to pay falls to $0.21. If the $4 observations are also eliminated, the average falls to $0.19. In all cases, the stated willing to pay for this information results in pretty similar levels of benefits.

Table 5.1-10 Willingness to Pay for Displays at Bus Stops

Willingness to Pay (WTP) for Arrival Information				
WTP Amount ($)	**Total**	**Percent**	**WTP?**	**Total $**
$0.00	517	79%	N	$0.00
$0.50	37	6%	Y	$18.50
$1.00	64	10%	Y	$64.00
$2.00	9	1%	Y	$18.00
$3.00	8	1%	Y	$24.00
$4.00	3	0%	Y	$12.00
$5.00	3	0%	Y	$15.00
$6.00	2	0%	Y	$12.00
other	8	1%	N	$0.00
Total Respondents	651	100%		$163.50
Average WTP				*$0.25*

Willingness to Pay for Shuttle Service

More than half of survey respondents (54%) are not willing to pay anything for a replacement shuttle for their trips. Depending on riders' financial situation and trip purpose, it is expected that those willing will pay vary sums for a replacement shuttle service in lieu of a 10-minute delay to the bus service. Table 5.1-11 shows the distribution. The modal amount riders are willing to pay is $1. The average amount they are willing to pay is $0.76. This is equivalent to the passenger value of time $0.76 for ten minutes, or $4.56 per hour.

Table 5.1-11 Rider Willingness to Pay (WTP) for Substitute Shuttle Service

Willingness to Pay (WTP) for Substitute Shuttle Service				
WTP Amount ($)	**Total**	**Percent**	**WTP?**	**Total $**
$0.00	347	53%	N	$0.00
$0.50	62	9%	Y	$31.00
$1.00	132	20%	Y	$132.00
$2.00	39	6%	Y	$78.00
$3.00	33	5%	Y	$99.00
$4.00	6	1%	Y	$24.00
$5.00	20	3%	Y	$100.00
$6.00	6	1%	Y	$36.00
other	9	1%	N	$0.00
Total Respondents	654	100%		$500.00
Average WTP				*$0.76*

Willingness to Pay for Alternative Taxi Service

More than half of survey respondents (57%) are willing to pay something for an alternative taxi service for their trips in case of a bus service shutdown. Riders' financial situations and trip purposes are expected to affect how much they are willing to pay for the taxi service if there is no bus service. Table 5.1-12 shows the distribution. The modal amount riders are willing to pay is $1. The average amount they are willing to pay is $1.08. This is equivalent to the average passenger value of a trip.

It is interesting to note in general that more people are willing to pay for an alternative when faced with a service shut-down than for a substitute when service is simply delayed. It is also notable, in general, that people are willing to pay about 40% more on average for an alternative when faced with service disruption than for a delay in service. It is quite revealing to note that the typical rider in all these cases is only willing to pay as much for an alternative as the cost of a one-way bus fare.

Table 5.1-12 Rider Willingness to Pay (WTP) for Taxi Alternative to Bus

Willingness to Pay (WTP) for Alternative (Taxi Service)				
WTP Amount ($)	**Total**	**Percent**	**WTP?**	**Total $**
$0.00	272	42%	N	$0.00
$0.50	57	9%	Y	$28.50
$1.00	163	25%	Y	$163.00
$2.00	46	7%	Y	$92.00
$3.00	51	8%	Y	$153.00
$4.00	8	1%	Y	$32.00
$5.00	35	5%	Y	$175.00
$6.00	10	2%	Y	$60.00
other	8	1%	N	$0.00
Total Respondents	650	100%		$703.50
Average WTP				*$1.08*

Available Alternatives

It is worth noting that nearly all or more than 95% of riders have alternatives available to the bus yet significant proportions were willing to pay for alternatives. Interestingly, half of the respondents indicate having a non-motorized (walk or bike) mode available. Auto modes (drive or get a ride) account for 45% of alternative mode availability. Table 5.1-13 shows the distribution.

Table 5.1-13 Alternatives Available to SLO Transit Riders

	Alternatives Available	Total	Percent
1	Walk or Bike	335	51.2%
2	Drive	194	29.7%
3	Get Ride	101	15.4%
4	Cancel Trip	21	3.2%
5	Other Mode	3	0.5%
	Total Respondents	654	100.0%

Auto Accessibility for Trip

In response to a separate question on whether respondents have access to a car for the trip, nearly two-thirds (64%) answered yes. The remainder (36%) answered no.

Gender of Riders

There are essentially an equal number of male as female riders on SLO Transit. See Table 5.1-14

Table 5.1-14 Gender Distribution of SLO Transit Riders

Gender	Total	Percent
Female	328	50%
Male	326	50%
Total Respondents	654	100.0%

Occupational Status

The overwhelming majority of riders (83%) are students. The next most group is made up of workers. Table 5.1-15 shows the distribution.

Table 5.1-15 Occupational Status of SLO Transit Riders

Occupation	Total	Percent
Student or trainee	543	**83.0%**
Employed full time	43	6.6%
Employed part-time	23	3.5%
Other SLO area resident	28	4.3%
Visiting SLO area	4	0.6%
Other	13	2.0%
Total Respondents	654	100.0%

Age Distribution

The overwhelming student ridership matches with the majority age group of 16 to 25, the dominant ages of college students. Table 5.1-16 shows the distribution.

Table 5.1-16 Age Distribution of SLO Transit Riders

Age Group	Total	Percent
16-25	537	**82%**
26-35	38	6%
36-45	14	2%
46-55	34	5%
56-65	16	2%
66-75	9	1%
Over 75	7	1%
Total Respondents	655	100.0%

5.2 Passenger Boarding Time Survey

The research included a passenger boarding time survey for both SLO Transit and the regional RTA bus system. The survey objective was to measure the extent to which the EDAPTS card-swipe devices reduce boarding times, as a basis for estimating the corresponding user benefits. The survey involved three major tasks: 1) Developing the Boarding Time Survey Program, 2) Conducting the Passenger Boarding Time Survey, and 3) Performing Preliminary Analysis of Passenger Boarding Time Data.

Boarding Time Survey Program (PC and PDA)

The boarding time survey was conceived as an observational process without direct interaction between surveyors and riders. Some passengers might not have realized these observations were being made, while others might have noticed. The approach was to time how long it took riders using various fare media to complete payment transactions on buses with and without the EDAPTS ITS technologies.

A Visual Basic (VB)-based computer program was developed to record the time each boarding passenger first stepped on the bus floor and the time that same passenger completed boarding by crossing the yellow line that is normally just behind the bus driver. Also of interest was whether passengers had to wait in queue before paying and the fare medium used. The developed computer program records, for each passenger, 1) boarding start time, 2) number of boarding passengers in queue, 3) fare medium used; and 4) boarding completion time.

The program permits these four items to be recorded with two key strokes for each boarding passenger. A tap of the “Enter” key or “Spacebar” records the start time of boarding, and successive taps accumulate the number of passengers in queue. A later tap of any numeric key between 1 and 7 records the type of payment for the first person in queue and the end of his or her boarding period. The program stores this information to a tab-delimited text file. The seven choices on the numeric keypad correspond to the available payment methods as follows:

1) Cal Poly ID Card
2) Monthly pass or ticket or transfer
3) Currency
4) Coin or token
5) Flash card
6) Other
7) Not a valid boarding transaction, that is, the observation is to be excluded.

Two versions of the boarding time program were created. One runs on a personal computer (PC) and the other runs on a Personal Digital Assistant (PDA). Figures 5.2-1 and 5.2-2 show the graphical user interfaces of the programs.

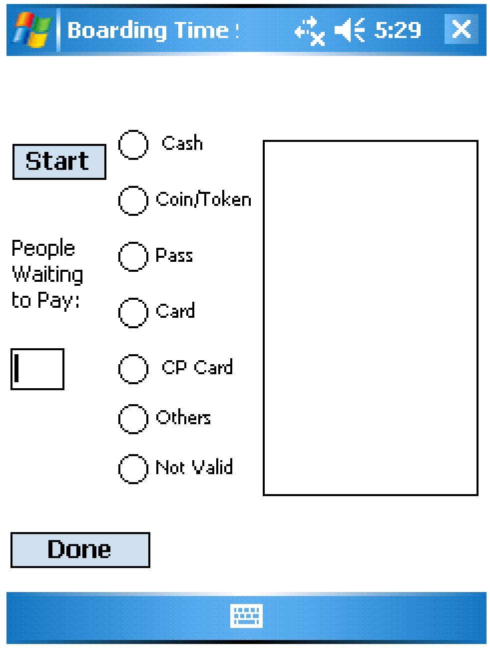

Figure 5.2-1: Boarding Time Survey Program (PDA Version)

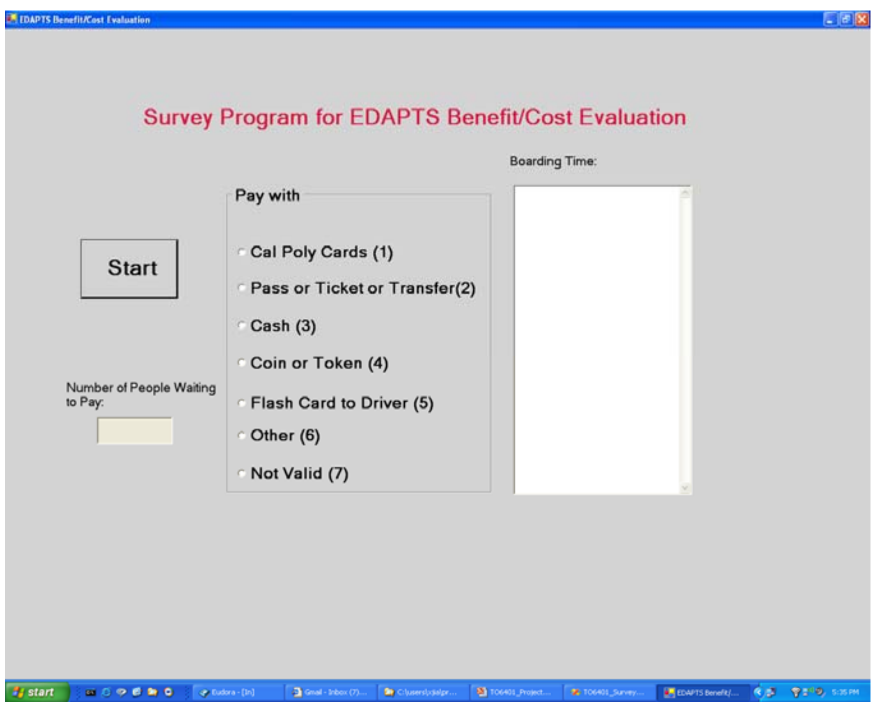

Figure 5.2-2 Boarding Time Survey Program (PC Version)

Boarding Time Survey Process

Two trained attendants sitting near the farebox alternated taking observations while riding each bus route. Data-collection schedules were established to obtain a random sample of SLO Transit bus routes and RTA bus routes. The RTA buses were originally included for the purpose of increasing the sample size of boarding observations unaffected by the EDAPTS technologies. Random sampling was applied to obtain variations in the hours of the day and days of the week when measurements were taken. All data was obtained on typical good-weather days with Cal Poly SLO in session.

Statistical considerations indicated that we should obtain a sample size of 400 good observations each for typical adult passengers paying cash, swiping a Cal Poly ID, or using another type of pass, for SLO Transit vehicles. For RTA buses, 400 observations each were sought for cash fares and passes. Thus, a minimum target of 2000 total data points was the target. These sample sizes were intended to ensure an error level in estimates of +/- 5% or smaller.

A series of trial runs were made to estimate the likelihood of lost observations in order to develop a final survey schedule that would provide the necessary data samples. The data-collection was coordinated with the appropriate bus system managers, and the drivers were informed. Two surveyors rode each bus both to relieve each other and so one attendant would be available to deal with any passenger inquiries regarding the survey or other issues that might arise.

Disparities in the choice of fare medium and ridership by route made it difficult to achieve targeted sample sizes in the key planned categories. The total valid data points obtained were as follows:

- Combined SLO Transit and RTA boardings of 948 for an error level of +/- 3.2%
- Total SLO Transit boardings of 837 for an error level of +/- 3.4%
- Total RTA boardings of 111 for an error level of +/- 9.3%
- Cal Poly ID boardings of 616 for an error level of +/- 4.0%
- Combined cash and token boardings of 142 for an error level of +/- 8.2%
- Combined monthly pass and flash pass boardings of 175 for an error level of +/- 7.4%

Preliminary Analysis of Boarding Time Survey Data

The following provides a summary overview of the data collected from the boarding time survey for both SLO Transit and RTA passengers. The charts are developed from data in the corresponding tables.

Types of Payment

Consistent with the passenger data, which reveals that 83% of riders are students or trainees is the finding from the boarding time survey that the Cal Poly ID card is used for payment by about 75% of SLO Transit riders captured in this survey. The Cal Poly ID card is not accepted on RTA buses. Cash/coins together and the monthly pass each account for about 10% of SLO Transit fares, but substantially larger portions of RTA fares paid. Table 5.2-1 and Figure 5.2-3 show the distribution of payment types.

Table 5.2-1: Distribution of Payment Types from the Boarding Survey

	SLO Transit		RTA	
	Count	Percent	Count	Percent
Currency	43	5.3%	41	37.3%
Coin	37	4.6%	17	15.5%
CPCards	604	74.7%	-	
Flash Cards	28	3.5%	27	24.5%
Pass	83	10.3%	24	21.8%
Other	14	1.7%	1	0.9%
Total	809	100%	110	100%

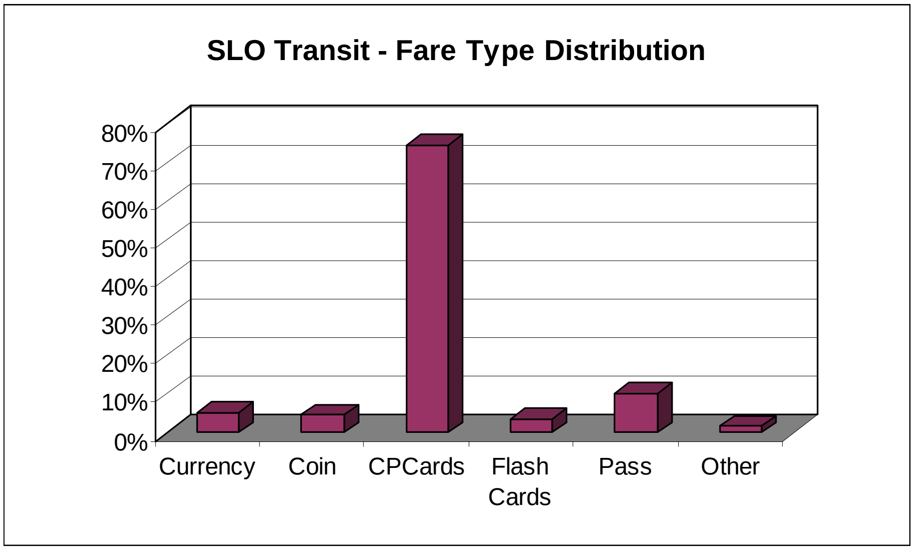

Figure 5.2-3 Distribution of Payment Types (SLO Transit)

Type of Payment vs. Time to Pay Fares

Examination of the time taken to pay fares when using the various payment types reveals that on average, the Cal Poly ID swipe card, an EDAPTS feature, exhibits a clear time advantage over all other payment media. Swiping the Cal Poly ID card takes less than half as long as most alternative methods, except for the flash card, which is close.

Table 5.2-2 and Figure 5.2-4 compare the lengths of elapsed fare paying times by payment type and by whether or not the passenger had to wait in queue to pay. Note that the average times shown represent only the times required to pay the fares, not the time spent waiting in queue for one’s turn to pay.

Table 5.2-2 Average Fare-Payment Times by Operator and Payment Types

		In Queue?	
	Medium	No	Yes
SLO Transit	Cash	6.4	6.0
	Coin	7.1	5.7
	CPCards	3.0	2.1
	Flash Card	4.3	2.8
	Pass	8.3	6.9
	All Media	4.4	3.0
RTA	Cash	9.5	4.8
	Coin	7.7	6.3
	CPCards	-	-
	Flash Card	7.7	3.8
	Pass	11.1	11.2
	All Media	8.5	6.3

Table 5.2-2 and Figure 5.2-4 provide some interesting comparisons. First, it is evident in Table 5.2-2 that, on average, boarding times on RTA buses are much longer than on SLO Transit buses, for nearly all fare media. This raises concern whether or not cash fares paid on RTA buses provide a valid basis for estimating time savings from swiping CPCards on SLO Transit. Upon further reflection, it is reasonable that the RTA boarding times systematically exceed SLO Transit’s. The RTA fare structure is more complicated, based on a zone system with amounts raging from $1 to $2.50 per ride, while the SLO Transit cash fare is either $1 (general) or $0.50 (seniors and handicapped). Consequently, it was decided to estimate time savings for CPCards using only the data from SLO Transit, despite the small sample size concerns.

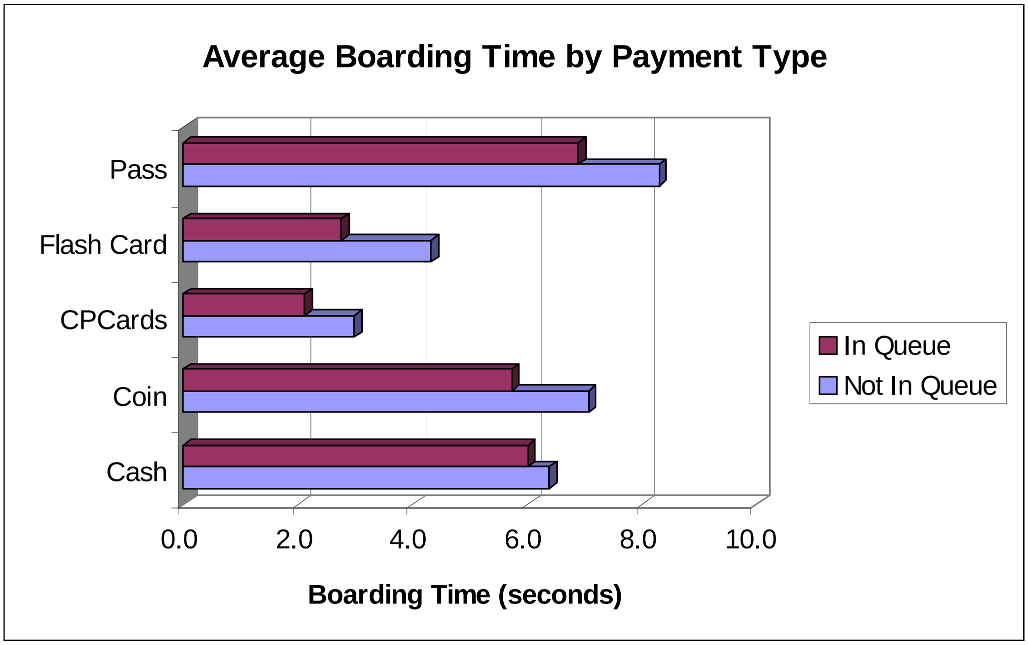

Figure 5.2-4 Average Fare-Payment Times by Payment Types (SLO Transit)

Another interesting comparison is related to whether or not a passenger is required to wait in queue before paying his or her fare. There is a consistent and, in some cases, a rather large time advantage in fare-paying if the passenger must first wait in queue. One explanation for this is that moving-up time is generally not counted for passengers in queue, while it is included in the fare-payment time when no queue is present. A second possible explanation is that, while waiting in queue, passengers can use the time by preparing to pay their fares quickly.

Boarding Time Savings Due to EDAPTS

Using the data summarized above, a simple calculation can be made to determine the average boarding time savings from using the EDAPTS card-swipe system. This calculation appears in Table 5.2-3 below. Note that, for the reasons previously discussed, only data from SLO Transit buses is used in this calculation.

As seen in the table, the average fare-paying time for passengers using CPCards is either 2.97 or 2.12 seconds, depending on whether or not there is a queue. This compares to weighted average delays of 6.92 and 5.99 seconds for the other payment types combined. The savings from the card-swipe system are therefore just about 3.9 seconds, whether or not a queue is present. Since 75% of SLO Transit passengers use CPCards, this corresponds to 2.9 seconds saved for the average passenger, whether or not he or she is a CPCard user.

The average savings of 2.9 seconds per boarding is used in Section 5.5 to calculate the travel time benefits to passengers of the EDAPTS card-swipe system.

Table 5.2-3 Calculation of Average Boarding Time Saved by EDAPTS

Average non-CPCard time without queue =	6.92
Average non-CPCard time with queue =	5.99
Average CPCard time without queue =	2.97
Average CPCard time with queue =	2.12
CPCard savings without queue =	3.95
CPCard savings with queue =	3.87
% of SLO fares without queue =	60.8%
% of SLO fares with queue =	39.2%
Weighted average CPCard savings =	3.9
Percentage of valid boardings w/ CPCards =	75%
Average boarding time savings per passenger =	2.9

5.3 Driver Survey

The project conducted a driver survey for the SLO Trans EDAPTS System. It involved tasks including 1) Interview Guide Development, 2) Driver Survey Administration, and 3) Preliminary Analysis of Driver Survey Data.

Interview Guide Development

An interview guide was prepared to help the surveyor elicit information on the benefit measures of performance of interest to bus drivers. The survey focused on drivers' perceptions about the presence and magnitude of improvements to bus services enabled by the new technologies, and how much value, in dollar terms, drivers attribute to the changes that directly affect them on the job.

Conforming to the basic hypotheses underlying this research was the notion that the EDAPTS ITS technologies improve bus services in several ways, leading to more efficient operations, improved safety, travel time savings, and greater employee satisfaction, all of which can be expressed in terms of specific dollar-quantified benefits.

This interview guide was approved by the Human Subjects Committees of Cal Poly SLO, Cal Poly Pomona, and California PATH. The interview guide is included in Appendix A.

Driver Survey Administration

To gather the necessary data regarding possible benefits to bus drivers, the study team conducted face-to-face in-depth interviews to assess drivers' reactions to the EDAPTS ITS technologies. These interviews were arranged to take place at the SLO Transit bus dispatch office, at times when drivers finished their runs for the day and are normally at the facility. We attempted to interview all SLO Transit drivers, but because participation was voluntary, some drivers declined to be interviewed.

Due to the small population size (two dozen), we assumed the results apply to the full population and sampling was not relevant. Each interview was carried out by a trained interviewer, who loosely followed the standard script provided, making adjustments to the script as needed to fit previous responses. Although interviewers were introduced to the drivers and therefore knew the drivers' names at the times of the interviews, the identities of the drivers were not recorded, as they were advised that the information they provided was recorded anonymously.

Preliminary Analysis of Driver Survey Data

The following is a summary of responses from the driver interviews. Because of a low numbers of responses, the information is summarized in the form of descriptive text instead of tables.

Emergencies

Responding drivers have little to no experience with intruders or being threatened while on duty. During emergencies, respondents almost always use the radio to get in touch with dispatch, instead of personal cell phones or the panic button (which is not currently operational).

Schedule Adherence

Although more than half of the respondents did not drive for SLO Transit prior to EDAPTS deployment, all respondents agree that EDAPTS ITS features help them stay on schedule.

Willingness to Pay

If a "benefit" account of $20 were set up to be used toward incidental personal expenses, respondents would be willing to spend on average $11.80 of that sum of money to retain each of the EDAPTS ITS features: 1) GPS tracking and 2) schedule adherence.

5.4 Transit Administrator Survey

The project conducted a transit administrator survey concerning the SLO Transit EDAPTS System. It involved tasks including 1) Interview Guide Development, 2) Transit Administrator Survey Conduct, and 3) Preliminary Analysis of Transit Administrator Survey Data.

Interview Guide Development

An interview guide was prepared to help the surveyor elicit information on the benefit measures of performance of likely interest to transit administrators. The survey focused on perceptions about the presence and magnitude of improvements to bus services enabled by the new technologies, and how much value, in dollar terms, the respondents attributed to these changes.

Conforming to the basic hypotheses underlying this research was the notion that the EDAPTS ITS technologies improve bus services in several ways, leading to more efficient operations, improved safety, travel time savings, and greater satisfaction among customers and employees, all of which can be expressed in terms of specific dollar-quantified benefits.

This interview guide was approved by the Human Subjects Committees of Cal Poly SLO, Cal Poly Pomona, and California PATH. The interview guide is included in Appendix B.

Administrator Survey Conduct

To gather the necessary data regarding possible benefits to SLO Transit and the transit operator, we conducted face-to-face, in-depth interviews with all individuals involved in administering and running the system. These interviews were conducted at pre-arranged times at the offices of these individuals. They included key personnel of the contractor (First Transit) that runs the buses under contract with the City of SLO, including managers, supervisors, and dispatchers.

Due to the very small population size (less than a half dozen), we assumed the results apply to the full population and sampling was not relevant. Each interview was carried out by a trained interviewer, who loosely followed the guide provided, making adjustments to the script as needed to fit previous responses. Although interviewers were introduced to the respondents and therefore knew their names, identities were not recorded. Respondents were advised that the information they provided was recorded anonymously.

Preliminary Analysis of Administrator Survey Data

The following is a summary of responses from the administrator interviews. Because of the very low numbers of responses, the information is summarized in the form of descriptive text instead of tables.

Fare Collection

The automatic fare collection feature helps in enforcement since there is active card validation. It does not translate readily to savings in person hours.

Stress Reduction and Schedule Adherence

EDAPTS ITS features do not contribute significantly to reduction in stress on drivers. The contract penalties element to be associated with schedule adherence has not been implemented, so no benefits could be identified. The sentiment of respondents is that the log information produced by EDAPTS could help the transit system manager levy increased penalties.

GPS Tracking

GPS could help confirm the position of a bus, but this is not the primary method used to detect if a breakdown has occurred. As indicated in the driver interviews, radio is predominantly used to report emergencies. Breakdowns reportedly occur once in nearly three months (once in eleven weeks). The constant nature of GPS tracking enables bus locations to be monitored every 40 to 50 seconds. Similarly drivers are able to report emergencies by radio within the first minute of occurrence.

Schedule Coordination and Reliability

These features simply aid the drivers to adhere more easily to the schedule. They cause no real difference in schedule coordination at transfer locations in the view of administrators.

Customer Complaints

On average, customer service receives fewer than two complaints per month. Respondents concur that a fair number of customer complaints are eliminated by using information generated by the EDAPTS system. The EDAPTS is not used to collect data for reporting to FTA, but rather as support for driver discipline related issues.

Other Information

Other miscellaneous items of information provided by SLO Transit Administrators to aid the B/C evaluation are the following:

- There are 159 individual runs per weekday, 60 per weekend day. These add up to 915 runs per week and 47,580 per year.

- The operation uses 21 drivers each week of which up to 15 are on duty per weekday

- The average driver salary is $11.50 per hour and full time drivers work for 37 hours per week

- There have been no noticeable changes in trip times with and without EDAPTS. The key benefit to riders is to ensure that buses do not run ahead of schedule.

- There has been no reduction in vehicle operation and maintenance cost due to EDAPTS

- There has been no reduction in accidents due to EDAPTS

- Since EDAPTS is used mainly to verify customer complaints, reduction in customer complaints due to the technology is estimated by respondents at about 10%.

- There is no administrative cost savings attributable to EDAPTS.

It is worth noting that much of the lack of improvement perceived by SLO Transit Administrators may be due to the fact that EDAPTS was implemented in their first year of contracting to provide the service. There was not an established history on system operation prior to EDAPTS from their perspective.

5.5 Benefit Data Analysis

Using the data collected from the passenger questionnaire survey, the passenger boarding time survey, and the interviews with SLO Transit drivers and administrators, a wide range of system benefits were quantified in dollars. This section describes this quantification process.

Benefit Categories

Information gathered from three groups of respondents – passengers, drivers and administrators – was designed to characterize several performance measures related to the EDAPTS ITS technologies. These technologies are expected to improve bus services in several ways, leading to more efficient operations, including travel time savings, increased bus patronage, and greater stakeholder satisfaction. This study sought to quantify as many of these benefits as possible in dollar terms.

A dozen individual benefit measures are presented in the next section. They variously affect each of the three respondent groups and are related to:

- Electronic fare collection

- Schedule reliability
- Panic button
- GPS tracking
- Real-time information
- Real time data
- Schedule coordination
- Parking cost
- Reduced operating and maintenance costs
- Reduced accident costs
- Reduced emissions costs
- Reduced customer complaints.

It should be noted that civic pride was initially included as a possible benefit but was found not to be readily quantifiable.

Quantification of Benefits

Electronic Fare Collection

Benefits of using Electronic Fare Collection (EFC) in the SLO Transit EDAPTS System were quantified using the Stated Preference (or the willing-to-pay) method to quantify passengers' value of time combined with the analysis of boarding times described previously in Section 3.5. Table 5.5-1 shows the quantified benefits of electronic fare collection that accrue from savings in boarding times and consequently in en-route travel times. The following are noteworthy:

1) Travel time savings from electronic fare collection that accrue to SLO Transit passengers amount to 40 seconds per trip, totaling 9,726 hours per year. Note that this benefit is very large due to the fact that 75% of SLO Transit trips are made by Cal Poly affiliates who use the EDAPTS card-swipe device, thereby saving an average 3.9 seconds per boarding.

2) Service operators indicate that there is no administrative cost reduction from less cash handling and accounting/reporting for fares paid to SLO Transit, so no benefits are claimed on this basis.

Table 5.5-1 Quantification of Benefits due to EFC

Benefit Components	Benefits to Whom?	How to Measure	Quantified Benefit	Units
Running time savings from EFC	Passengers	Measure boarding times w/ & w/o EDAPTS, accumulate to running times and value of reduced travel times		
Section 5.2 (Table 5.2-3)	**a**	Average fare-payment time saving with EDAPTS	2.9	sec/boarding
Section 3.5	**b**	Average time saving per trip	40	sec/trip
NTD data (Table 19, 2005)	**c**	Total SLO Transit trips	875,354	boardings /yr
b * c	**d**	Total time savings with EDAPTS	35,014,160	sec /yr
	e		9,726	hr /yr
Section 5.1 (Table 5.1-12)	**f**	Passenger value of time	$4.56	$ per hour
e * f	**g**	Total passenger benefit	$44,351	$ per year

Schedule Reliability

This research used the stated preference (or the willing-to-pay) method to quantify benefits of the SLO Transit EDAPTS System in terms of schedule reliability improvements. Table 5.5-2 shows the quantified benefits of increased schedule reliability. The following are noteworthy:

1) Drivers perceived a value to them in: (a) reduced stress; and (b) ability to stay on schedule and allow passengers to make transfers; to the tune of $2,873 per year.

2) On the contrary, service administrators indicate that there is no transfer of the value of schedule reliability to drivers onto SLO Transit.

3) Revenue increases from increased ridership from more reliable performance are not really benefits to SLO Transit; they are transfers of a part of total passenger benefit that is not considered consumer surplus.

Table 5.5-2 Quantification of Benefits due to Reliability

Benefit Components	**Benefits to Whom?**	**How to Measure**	**Quantified Benefit**	**Units**
Value to drivers in reduced stress, ability to stay on schedule and allow passengers to make transfers	Drivers	Contingent value of perceived benefit, measured from survey		
data	**a**	Willingness to pay for technology	$11.40	per month
data	**b**	Total drivers	21	
a * b	**c**	Total driver benefits	$239.40	$ per month
c * 12	**d**	Total driver benefits	$2873	$ per year

Panic Button

The panic button is not currently in use; the radio is used almost always to summon help quickly in an emergency. There is therefore no quantifiable value of the panic button to drivers or SLO Transit

GPS

It was anticipated that the impact of GPS in monitoring driver job performance and supervision on SLO Transit could be measured in terms of labor cost reduction from improved discipline. Administrators indicate, however, that no such benefit accrues.

Real-Time Information

Table 5.5-3 shows the quantified benefits of having real-time information signs on the transit service. The following are noteworthy:

1) The value to passengers of knowing arrival times - reduced stress, improved certainty, activity planning - for regular passengers amounts to $98,477 per year.

2) For occasional passengers who might ride on rainy days, or during special events, etc., the value of knowing arrival times - reduced stress, improved certainty, activity planning – is included in the estimated value for regular passengers.

Table 5.5-3 Quantification of Benefits due to Availability of Information

Benefit components	Benefits to whom?		How to measure	Quantified Benefit	Units
Value to passengers of knowing arrival times - reduced stress, improved certainty, activity planning - for regular passengers	Passengers		Contingent value of perceived benefit, measured by survey		
Passenger survey (see Table 5.1-10)		a	average value of sign per ride	$0.25	per ride
NTD data (Table 19, 2005)		b	Total SLO Transit boardings	875,354	boardings per year
Estimated from passenger survey (Section 3.4)		c	Percent of boardings at stops with displays	45%	
b * c		d	Boardings at stops with displays	393,909	
a * d		e	Total benefits over all passengers	$98,477	$ per year

Real Time Data

It is anticipated that there will be a benefit to SLO Transit from increased ridership due to the availability of real-time traveler information. This was previously quantified for passengers. The difference between the full value of the trip to passengers and the transfer to SLO Transit in the form of increased fare revenue is the consumer surplus, an added benefit.

Table 5.5-4 shows the quantified benefits. Revenue increases from increased ridership from real-time passenger information are not really benefits to SLO Transit; they are transfers of a part of total passenger benefit that is not considered consumer surplus.

Table 5.5-4: Quantification of Consumer Surplus due to Real-Time Information

Benefit Components	Benefits to Whom?	How to Measure	Quantified Benefit	Units
Benefit from increased ridership from having traveler information	SLO Transit & passengers	Increased Revenue ($/rider)		
Inferred from passenger survey (Table 5.1-9)	**a**	Avoided ridership loss = gain	8.40%	
NTD data (Table 19, 2005)	**b**	Total SLO Transit boardings	875,354	boardings per year
a * b	**c**	Total boardings gained	73,530	
Section 5.1 (Table 5.1-12)	**d**	Passenger's value of the trip	$1.08	$ per trip
c * d	**e**	Total benefit	$79,412	$ per year
NTD data (Table 26, 2005)	**f**	Revenue per boarding (average fare per ride)	$0.50	$ per ride
c * f	**g**	Transfer to Transit Agency (increased revenue)	$36,765	$ per year
e - g	**h**	Consumer surplus	$42,647	$ per year

Schedule coordination

It is anticipated that there will be a value of reduced trip times from improved schedule coordination (SLO-to-SLO and SLO-to-RTA). However administrators indicated that there is no value of trip time saved.

Reliability

It is anticipated that there will be a value of reduced trip times from improved schedule reliability. However administrators indicated that there is no value of trip time saved.

Parking Cost

It is anticipated that there may be indirect benefit to the community (e.g. the university) due to increased ridership to be measured in terms of the avoided cost of new parking provision. Table 5.5-5 shows the quantified benefits. In the case of SLO Transit, approximately one parking spot is saved at an estimated benefit of $1,468 per year to the Cal Poly SLO University.

Table 5.5-5 Quantification of Benefits due to Avoidance of Parking Provision

Benefit Components	Benefits to Whom?	How to Measure	Quantified Benefit	Units
Indirect benefit to university and community due to increased ridership (less parking needed)	Community	Avoidance of cost of new parking construction($/space)		
Estimated from passenger survey	**a**	Increased ridership due to reliability	35014	per yr
MOP #16 in Table 4.1-1	**b**	Increased ridership due to information MOP #16	73,530	per yr
max (a,b)	**c**	max ridership gained	73,530	per yr
data	**d**	% student ridership	65%	per yr
d * c	**e**	student ridership gained	47794	per yr
Brown, Shoup et al, 1999	**f**	annual rides per eligible campus affiliate	30	per yr
e / f	**g**	Number of people displaced from University parking needs to SLO Transit	1593	per yr
	g-1	Percent single occupant (or single occupant vehicle (SOV)) commuters	0.85	
	g-2	Number of SOV commuters	1354	
	h	Regular activity days per year	1500	per yr
g / h	**i**	Parking space saved from construction	0.90	
	j	Amortized capital cost of 1 surface parking space	$99	per month[1]
	k	Annual operating and maintenance cost per space	$36.50	per month[2]
(k + j) * I *12	**L**	Total cost savings	$1,468	$ per year

[1] *Based on $15,000 for 20 years at 5% discount rate;*
[2] *Maintenance at 1.0% of capital cost per year and Operating at $1.20 per day and 20 days per month*

Reduced O&M Costs

It is anticipated that there will be a reduction in transit operating and maintenance (O&M) costs from the EDAPTS ITS technologies. However administrators indicated that there is no reduction in such costs attributable to EDAPTS.

Reduced Accident Costs

It is anticipated that there will be a reduction in accident costs from the EDAPTS ITS technologies. However administrators indicated that there is no reduction in such costs attributable to EDAPTS.

Reduced Emissions Costs

It is anticipated that there will be a reduction in emissions costs from the EDAPTS ITS technologies. However administrators indicated that there is no reduction in such costs attributable to EDAPTS.

Reduced Complaints

It is anticipated that there will be a reduction in costs in relation to dealing with customer complaints due to the EDAPTS ITS technologies. Administrators indicated that there is no reduction in such costs attributable to EDAPTS. Administrators guessed, however, that there could be reduction in complaints to the order of 10%.

Civic Pride

It is anticipated that there will be a value of civic pride and satisfaction in having a progressive, well run transit system due to the EDAPTS technologies. This was found not to apply to this research.

6. COST DATA COLLECTION

This section describes the cost data collection process and provides a preliminary analysis of the cost data for the economic assessment of the SLO Transit EDAPTS system.

6.1 Cost Data Identification[3]

There are two types of cost items involved in the SLO Transit EDAPTS system: research/development costs and test deployment costs. The research/development costs are associated with the design, development and testing of the EDAPTS system. The test deployment costs consist of the costs of the EDAPTS components and the costs associated with the installation, operation, and maintenance of the EDAPTS system.

Under the research funding provided by Caltrans, the Cal Poly SLO research team led by Jeff Gerfen started the development of the first EDAPTS system in early 2001. The system was designed to be consistent and compliant with both the National ITS Architecture and Transit Communications Interface Profiles (TCIP) Standards to the maximum extent possible. Functions of the EDAPTS components were decomposed according to the National ITS Architecture process specifications (PSPECS) and all data objects were encoded as TCIP objects. The system was then developed using off-shelf equipment and built from scratch. The system progressively evolved to be the first low cost, easy to be deployed APTS system that was suitable for small or medium-size transit agencies. The SLO Transit EDAPTS system is non-proprietary. Its source code is open to transit communities.

This project did not consider the research/development costs or funds for the economic assessment of the SLO Transit EDAPTS system. Transit agencies willing to adopt an EDAPTS system normally most likely do not care about how many funds were spent in the development of the SLO Transit EDAPTS system. Instead, they would care about the costs associated with the test deployment of the EDAPTS system in SLO transit. Also they would like to know if the system is economically sound for SLO Transit.

In considering the above issues, this project concentrated on the costs incurred for the test deployment of the EDAPT system at SLO Transit. The cost items considered in this project were derived directly from the components of the SLO EDAPTS system.

There are four major components within the SLO Transit EDAPTS system. These components are as follows:

[3] Adapted from "EDAPTS: Smart Transit System, California Polytechnic State University & Caltrans Research and Innovation, Jeff Gerfen, Project Director", undated

Mobile Data Terminals and On-Board Hardware

Mobile Data Terminals (MDTs) and On-Board hardware are installed on SLO Transit buses. Each MDT includes 1) a driver's keypad and display, 2) an integrated GPS receiver, 3) a magnetic swipe card reader, 4) an emergency button, and 5) a data interface to a voice radio system.

This project assumed that these MDTs and vehicle On-Board hardware can be packaged to be commercial products. The unit price of these products was defined to reflect the costs of off-shelf components assembled in the MDTs and On-Board hardware. Additionally the project considered the costs associated with the installation, operation, and maintenance of these products.

Central Dispatch Software

The Central Dispatch Software is the core part of the SLO Transit EDAPTS system. This includes the server processes required to run the system, the communication modules necessary to communicate with other EDAPTS components, and the ATRMS software client used by dispatch and management users to interact with the system and view the collected operational data. It utilizes Transmission Control Protocol/Internet Protocol (TCP/IP) technologies for communications among EDAPTS processes and a Sybase database for storing operational data of SLO Transit service. It manages operations of all buses and displays schedule adherence information at all stops.

It should be noted that the EDAPTS ITS system is an open-source system. The Central Dispatch Software does not have unit cost. Transit agencies willing to adopt the EDAPTS ITS system can refine the free Central Dispatch Software for their own operating environment. This research only considered the costs associated with the installation, operation, and maintenance of the Central Dispatch Software.

Smart Transit Signs

Eight smart transit signs are installed on SLO Transit routes. These smart transit signs are solar powered and are capable of operating for up to 20 days of inclement weather. They are housed in a heavy-duty enclosure and are vandal and weather resistant. The signs are pager controlled allowing all signs in San Luis Obispo to be controlled with a single paging account. Additionally, these signs are capable of displaying not only estimated minutes until arrival for multiple routes but also repeated text banners.

This project assumed that these smart transit signs can be packaged to be commercial products. The unit price of these products was defined to reflect the costs of off-shelf components assembled in the signs. Additionally the project considered the costs associated with the installation, operation, and maintenance of these products.

Web-Map for Public Use

The SLO Transit EDAPTS system allows transit passengers to view vehicle location on a map-based display via the Internet. Passengers can turn individual routes on and off as well as enter their local address and have their location displayed on the map.

It should be noted that the EDAPTS ITS system is an open-source system. The map-based functions do not have unit cost. Transit agencies willing to adopt the EDAPTS ITS system can refine the free map-based functions for their own operating environment. This research only considered the costs associated with the installation, operation, and maintenance of the map-based functions.

6.2 Cost Data Collection

Using the cost items as the guideline for data collection, this project collected cost data (in dollars) from a survey of typical prices of the various components used in the design of the SLO Transit EDAPTS system. The survey included online price checks, visits to local retail establishments and calls to manufacturers and vendors of specialized items. The "best" prices of individual subcomponents were compiled for inclusion in the cost data. Labor time estimates were based on the times spent previously and in other ongoing EDAPTS projects in the installation of EDAPTS components and software programs.

Cost data collected for B/C ratio analysis are divided into two groups: fixed and recurring costs. The fixed cost components considered in the B/C ratio analysis are

- Mobile Data Terminal with mounts, GPS antenna, and magnetic stripe card reader
- Smart Transit Sign with paging receiver and solar power equipment
- Smart Transit Sign engineered post with installed foundation
- Radio and radio-modem set with installation in vehicle
- Central Dispatch Workstation
- Central Dispatch Server
- Software

The recurring cost components considered in the B/C ratio analysis are 1) monthly radio service (per bus) and monthly pager service.

6.3 Cost Data Processing and Preliminary Analysis

Table 6.1 lists the various components and associated per unit costs. The table also identifies the quantities and total costs of the components used in the installation of the SLO Transit system. It is noteworthy that Year 2007 prices were used in this analysis to correspond with the

Year 2007 benefits data. The total cost for the configuration of the SLO Transit EDAPTS system is lower than $150,000 at 2007 unit prices.

Table 6.1 Prices of EDAPTS Cost Components

Component	SLO Transit Quantities	Current Per Unit EDAPTS Component Cost Estimates (2007)	Current Per Unit EDAPTS Component Construction Labor Time Estimates in hours (2007)	Current Per Unit EDAPTS Installation Labor[2] Time Estimates	Current Per Unit EDAPTS Annual Maintenance Labor Time Estimates	SLO Transit EDAPTS Total Component Cost Estimates (2007)
Fixed Costs						
Mobile Data Terminal with mounts, GPS antenna, and magnetic stripe card reader	15	$1,747	7.00	3.50	6.00	$37,615.88
Smart Transit Sign with paging receiver and solar power equipment	9	$3,179	16.00	9.00	2.00	$ 44912.25
Smart Transit Sign engineered post with installed foundation	7	$2,350	2.00	4.00	0.00	$19,492.90
Radio and radio-modem set with installation in vehicle	15	$1,700	$0	2.50	1.00	$28,216.88
Central Dispatch Workstation	2	$700	$0	0.75	0.00	$1,508.68
Central Dispatch Server	1	$1,700	$0	1.25	2.00	$1,790.56
Software	1	$0	$0	160.00	88.00	$11,592.00
Recurring Costs						
Radio service (per bus)[1]	18	$17 /mo.				$ 3726.00 /yr.
Pager service	1	$55 /mo.				$660.00 /yr.
Total						$ 149515.134

Notes:

[1] *Cost is for single radio channel. Current EDAPTS installation in San Luis Obispo share existing voice channel, effectively providing free data communications. A separate dedicated channel is recommended.*

[2] *Labor rate assumed to be $72.5 per hour*

7. BENEFIT/COST EVALUATION

Using the benefits and costs quantified in dollars, the project conducted the benefit/cost ratio analysis and evaluated the sensitivities of B/C ratios to discounted rates and life cycles of the SLO Transit EDAPTS system. This section presents the detailed analysis.

7.1 Benefit/Cost Methodology

The Benefit-Cost evaluation methodology was described in Section 3. It is noteworthy that the method used in this research is a slight variation of the traditional method of matching the total of a series of discounted benefits to the total of a series of discounted costs. Instead, total capital costs were annualized and added to annual operating and maintenance costs in current dollars. Then the annual benefits were compared with annualized costs to derive ratios of annual benefit to annual costs. This was just done for convenience since most cost and benefit data were originally in annualized form. Using annualized data has no effect on the calculated B/C ratio values.

7.2 Quantified Benefits

Table 7.2-1 presents a summary of quantified benefits elicited from the survey data. The derivation and estimates of various categories of benefits were previously presented in section 5.5.

There are two types of benefits generated by the SLO Transit EDAPTS system: conventional benefits and consumer surplus. Conventional benefits are the benefits directly measured using the “willing to pay” principle for existing passengers, as well as for drivers and SLO Transit administrators. Consumer surplus is the difference between the price consumers (passengers) are willing to pay and the actual price charged by the SLO Transit.

The total quantified annual benefits as shown in Table 7.2-1(a) are approximately $226,600. They include conventional benefits and consumer surpluses estimated for passengers who receive real time bus arrival information from the SLO Transit EDAPTS system. If the consumer surpluses were not considered, the estimate of total benefits would fall to approximately $184,000, as shown in Table 7.2.1(b).

It should be noted that all the benefits and consumer surplus were quantified using dollars in year 2007 since surveyed passengers, riders, and SLO administrator answered the “Willing to Pay” questions in 2007. Additionally, this project assumed that the quantified benefits and consumer surpluses remain unchanged with the life cycle of the SLO Transit EDAPTS system. In other words, ridership growth is assumed to be zero. This assumption provides a conservative B/C ratio estimate since benefits and consumer surpluses would be expected to increase from the increased ridership.

Table 7.2-1 (a): Summary of Quantified Benefits (with Consumer Surplus)

Benefit Components	Quantified Benefit	Units	Beneficiary
Quantified benefits of **electronic fare collection (see** Table 5.5-1)	$44,351	$ per year	Passengers
Quantified benefits of increased **schedule reliability (see** Table 5.5-2)	$2,873	$ per year	Drivers
Quantified benefits of having **real-time information signs** (see Table 5.5-3)	$98,477	$ per year	Passengers
Quantified **increase in fare revenue due to Real-Time Information (see** Table 5.5-4)	$36,765	$ per yr	SLO Transit
Quantified **consumer surplus due to Real-Time Bus Arrival Information (See** Table 5.5-4)	$42,647	$ per year	passengers
Quantified benefits due to **avoided parking costs (see** Table 5.5-5)	$1,468	$ per year	Community
Total of All Benefits	**$226,581**	**$ per year**	**All Beneficiaries**

Table 7.2-1 (b): Summary of Quantified Benefits (without Consumer Surplus)

Benefit Components	Quantified Benefit	Units	Beneficiary
Quantified benefits of **electronic fare collection (see** Table 5.5-1)	$44,351	$ per year	Passengers
Quantified benefits of increased **schedule reliability (see** Table 5.5-2)	$2,873	$ per year	Drivers
Quantified benefits of having **real-time information signs** (see Table 5.5-3)	$98,477	$ per year	Passengers
Quantified **increase in fare revenue due to Real-Time Information (see** Table 5.5-4)	$36,765	$ per yr	SLO Transit
Quantified benefits due to **avoided parking costs (see** Table 5.5-5)	$1,468	$ per year	Community
Total Benefits Excluding Consumer Surplus	**$183,934**	**$ per year**	**All Beneficiaries**

7.3 Quantified Costs

Table 7.3-1 presents a summary of costs associated with implementation of the SLO Transit EDAPTS system. As described in Section 6, there are two types of costs involved in the EDAPTS system: fixed costs and recurring costs. The Operating and maintenance costs, considered as recurring costs, were held at 2007 dollars. The capital costs, considered as fixed costs), were annualized at 7% discount rate over five-, seven-, and ten-year periods. The three life cycles (5-year, 7-year and 10-year) were applied for sensitivity analysis. EDAPTS components implemented in the SLO Transit system were anticipated to last for at least five years, but some components could last much longer. The five-year life cycle represents the most conservative analytic scenario.

Discount Rates

A discount rate of 5% was initially used to annualize capital costs. The rate was determined by examining the range of current US Bond Market Rates for medium to long-term investments. A collection of rates in effect in September, 2007 is presented in Appendix C. The discount rate of 5% is the lowest of the various rates examined. It was adopted for a conservative estimate. We also used the discount rate of 7% as required by the US Office of Management and budget (OMB) for Benefit/Cost Analysis of public investments. For further sensitivity analysis, a rate of 10% representing two times the bond rate was also applied.

Annualized Cost Calculation

Capital cost (C_1) data for various EDAPTS components were converted to equal annual payments (*AC*) over the economic life or service life (*n*) of each improvement at the discount rate (*i*) of 5%, 7%, and 10%. The equation for equalized annual capital costs is as follows:

$$AC = C_1 * \frac{i(1+i)^n}{\left[(1+i)^n - 1\right]}$$

Where:

AC is the equalized annual capital cost;
C_1 is the estimated capital cost of the proposed improvement;
i is the assumed discount rate per year;
n is the economic life of the improvement in years.

Capital cost data and the assumptions for discount rate and economic life were applied to find the annual amounts that would make the capital investments go to zero at time n. For simplicity, EDAPTS components were not assumed to have any residual values at the end of their economic lives.

Table 7.3-1 shows that the total fixed cost of $145,130 (in 2007 dollars) incurred in implementing EDAPTS ITS technologies on SLO Transit translates to $42,570 in annualized costs over 5 years, assuming a 7% discount rate. There is an additional annual recurring cost of $4,390.

Annual operating and maintenance costs were calculated in constant (2007) dollars. For each component, the annualized capital cost and the annual operating and maintenance costs were added to obtain the total cost per year over the economic life. They add up to a total of $46,960 annualized costs per year (assuming 5-year life cycle). Maintenance costs were assumed to be 1.0% per year of total capital costs.

Table 7.3-1: Summary of Quantified Costs

7% Discount Rate	5-Year Term	7-Year Term	10-Year Term	Units
Total Fixed Costs	$42,568	$34,102	$27,836	$ annualized
Mobile Data Terminal with mounts, GPS antenna, and magnetic stripe card reader	$9,609	$7,414	$5,790	$ annualized
Smart Transit Sign with paging receiver and solar power equipment	$11,099	$8,479	$6,539	$ annualized
Smart Transit Sign engineered post with installed foundation	$4,754	$3,617	$2,775	$ annualized
Radio and radio-modem set with installation in vehicle	$6,954	$5,308	$4,090	$ annualized
Central Dispatch Workstation	$368	$280	$215	$ annualized
Central Dispatch Server	$582	$477	$400	$ annualized
Software	$9,203	$8,527	$8,026	$ annualized
Total Recurring Costs	$4,386	$4,386	$4,386	$ annualized
Monthly radio service (per bus)	$3,726	$3,726	$3,726	$ annualized
Monthly pager service	$660	$660	$660	$ annualized
Total Costs	**$46,954**	$38,488	$32,222	**$ annualized**

7.4 Benefit/Cost Ratios

Table 7.4-1 presents the benefit-cost ratio summary associated with implementation of the SLO Transit EDAPTS system for 7% discount rate. For each life cycle, two ratios are presented corresponding with whether the consumer surplus is included among user benefits or not. The most conservative analysis excludes consumer surplus as benefits and shows ratios of approximately 3.9 to 5.7. This means in general that every dollar invested in the SLO Transit

EDAPTS system resulted in at least four dollars of benefits to the constituent groups each year. Including consumer surplus causes the ratios to increase to between 4.8 and 7.0.

Table 7.4-1: Benefit/Cost Ratio Summary (with 7% Discount Rate)

	5-Year Term	**7-Year Term**	**10-Year Term**	**Units**	**Constituent**
Including Consumer Surplus					
Total of All Benefits	$226,581	$226,581	$226,581	$ per year	All beneficiaries
Total Costs	$46,954	$38,488	$32,222	$ annualized	transit agency
Benefit to Cost Ratio	4.8	5.9	7.0		
Excluding Consumer Surplus					
Total of All Benefits	*$183,934*	*$183,934*	*$183,934*	*$ per year*	*All beneficiaries*
Total Costs	*$46,954*	*$38,488*	*$32,222*	*$ annualized*	*transit agency*
Benefit to Cost Ratio	*3.9*	*4.8*	*5.7*		

7.5 Sensitivity Analysis on Discount Rates

Table 7.5-1 presents the results of the sensitivity analysis. Including consumer surplus, ratios range from 4.5 to nearly 7.5. Without consumer surplus, ratios range from 3.7 to 6.1. As before, ratios depict step increases from the shortest to the longest economic lives (or life cycles) tested. As discount rates go up, ratios decrease slowly. The findings that B/C ratios substantially exceed 1.0 certainly justify continuing efforts to commercialize EDAPTS ITS technologies.

Table 7.5-1: Sensitivity Analysis of Benefit/Cost Ratios

	5-Year Term	7-Year Term	10-Year Term
Including Consumer Surplus			
5% Discount Rate	5.0	6.2	7.5
7% Discount Rate	4.8	5.9	7.0
10% Discount Rate	4.5	5.5	6.4
Excluding Consumer Surplus			
5% Discount Rate	4.1	5.0	6.1
7% Discount Rate	3.9	4.8	5.7
10% Discount Rate	3.7	4.4	5.2

8. SUMMARIES AND CONCLUSIONS

This section provides summaries of primary findings of the B/C ratio analysis and outlines recommendations to the test deployment of EDPATS ITS technologies in small/medium transit agencies.

8.1 Major Findings and Conclusions

It is concluded from this research that the following findings provide the strong basis to recommend small/medium transit agencies for considering the deployment of EDAPTS ITS technologies:

1) Passengers of SLO Transit, as indicated from the questionnaire surveys, perceived substantial benefits of the EDAPTS ITS features. For example, 16% of respondents concurred that the bus arrival time displays did have effects on their decisions to ride. Survey results indicated that there would be an 8.4% reduction in rides (or trips) overall if there were no bus arrival time displays at stops. This indicated that the presence of the bus arrival time displays at stops indeed generated benefits in terms of ridership retention or gain.

2) Not all EDAPTS ITS features were found to be consistently beneficial to passengers, drivers and SLO Transit management. For instance, passengers were largely unaware of Global Positioning System (GPS) receivers on buses, and drivers and dispatchers valued the use of radios in emergencies over GPS. However, the GPS data did provide real-time information to SLO Transit in dealing with dispatching, schedule adherence, emergency responses, and passenger complaints.

3) It is interesting to note that more people were willing to pay for an alternative transportation mode when faced with a service shut-down than for a substitute when service was simply delayed. It is also notable that people were willing to pay about 40% more on average for an alternative transportation mode when faced with service disruption than with a delay in service. It is quite revealing to note that the typical riders were only willing to pay as much for an alternative mode as the cost of a one-way bus fare.

4) Surveys of passenger boarding times on buses indicated that boarding times vary among different payment types. On average, Cal Poly ID swipe card, a SLO Transit EDAPTS ITS feature, exhibited a clear time advantage over the use of other payment media by an average of 3.9 seconds per boarding. This indicated that using the Cal Poly ID swipe card to board buses can save, on average, substantial boarding times and in the long run facilitate schedule adjustments and reduce overall bus running times.

5) At a total initial investment cost less than $150,000, small and medium-size transit agencies can deploy EDAPTS ITS features relatively inexpensively, as demonstrated by the test deployment at SLO Transit. The annualized capital, operational and maintenance costs could range from $30,000 to $50,000 for an EDAPTS ITS system with a service life from 5 years to 10 years.

6) The total annual benefits generated from an EDAPTS ITS system, as identified in this research, could range from $185,000 and $225,000. They do not include additional benefits (such as civic pride) that cannot be easily quantified in dollars. The annual benefits substantially outweigh the annual costs.

7) The ratios of annual benefits to annual costs are at least 3.9:1 for the SLO Transit EDAPT ITS system. This strongly indicates that the EDAPTS ITS technologies are economically viable. One-dollar investment on the EDAPTS ITS technologies will generate at least $3.9 benefit to a transit agency.

In summary, this research conducted a comprehensive benefit/cost (B/C) ratio evaluation for the SLO Transit EDAPTS ITS system. The findings of this research conclude that the EDAPTS ITS technologies indeed are a low-cost, easily deployed, economically sound ITS solution to small/medium transit agencies.

8.2 Future Work

In spite of the comprehensive approach to this study, it fell short of certain other possible evaluations. First, the test deployment at SLO Transit was followed by both changes of operator and major revision in the routing of lines. This precluded us from making strong comparisons between before and after conditions especially in terms of travel time savings and schedule adherence. A future study is required to make this comparison.

It is also desirable to deploy EDAPTS at several transit properties and then conduct similar evaluations as conducted in this study. This would provide a pool of data from which to predict the potential benefits of future deployments of EDAPTS across a wide range of transit system and community types.

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10. APPENDICES

Appendix A Driver Interview Guide

Interview Guide for Bus Driver Survey

We are asking for your help in providing information to assess the possible benefits of the Smart Transit System components (termed EDAPTS) in use at SLO Transit. These components include: (a) mobile data terminals and automatic vehicle locators on buses; (b) central dispatch software for vehicle tracking; (c) emergency communications; and (d) electronic fare collection..

If you are willing, we would like to ask you a number of structured questions about your experiences and views about the impacts on drivers of some of these components. Note that the information you provide will be coded anonymously, and you cannot be personally identified with any answers you provide.

Are you willing to participate in this interview? (If not, the interview is over. Thank the driver for his/her time.)

A. Summoning Help or Reporting Status During Emergencies

A.1) About how frequently do you experience different kinds of emergencies when on duty? (Lead the driver through the categories and enter the answer on the line that is the most convenient period for reporting.)

	Breakdown or accident involving the bus	Intruder or threatening situation	External incident (road blockage, traffic jam, detour)
Number of emergencies per day, by type:			
Number of emergencies per week, by type:			
Number of emergencies per month, by type:			
Number of emergencies per year, by type:			
Enter any comments:			

Additional comment or explanation: ____
____
____

A.2) What methods do you use to communicate with dispatchers during **emergencies**? Indicate the percentage of time by type of emergency for all that apply. (Each column should add to 100%.)

	Accident or breakdown involving bus	Intruder or threatening situation	External incident (road blockage, traffic jam, detour)	Comments re. communication types?
Call with cell phone				
Call by radio				
Automatic detection through automatic vehicle location (AVL) and global positioning system (GPS)				
On-board panic button				
Other:________________________________				
If never experienced this type of incident, check column:				
Comments re. emegency types:				

Additional comment or explanation:____
____
____

A.3a) Have you personally experienced emergency situations as a bus driver without having Smart Transit features available (vehicle tracking, emergency signal).

- ❑ Yes

- ❑ No

A.3b) If YES, please estimate the typical amount of time saved with and without the Smart Transit System.

- ❑ Estimated time saved in response time when there is a breakdown or accident ________________________________
- ❑ Estimated time saved in response time when there is an intruder or threatening situation ________________________

Additional comment or explanation: ____
____
____

A.4) Now I'm going to ask you an unusual question to help us estimate the value of the Smart Transit components. Imagine that your employer, to boost morale, makes available to all employees an on-the-job gift package. It is an account containing $20 per month that you can use to buy work-related amenities, like snacks in the break room. However, you can't just take the cash. The $20/month can only be spent on things at work. Now imagine further that a SLO Transit budget shortfall requires that the GPS tracking and panic button features on the buses be removed. Would you be willing to use some of your gift account to chip in with other drivers to restore these features? If so, what's the maximum amount per month you'd be willing to chip in?

❑ Not willing to pay anything	❑ $0.50	❑ $1.00	❑ $2.00
❑ $3.00	❑ $4.00	❑ $5.00	❑ Other (how much?) $_______

B. Schedule Adherence, Making Timed Transfers and Stress Reduction

B.1a) Did you drive for SLO Transit before the Smart Transit System was installed?

- ❑ Yes
- ❑ No

B.1b) Do you think the Smart Transit System helps you stay on schedule?

- ❑ Yes
- ❑ No

Additional comment or explanation: ____
____

B.2) How does the schedule keeping feature of the Smart Transit System affect you on your job? (Check all that apply.)

- ❑ Reduces the difficulty and stress related to staying on schedule
- ❑ Improves my job performance
- ❑ Makes me proud to be an employee of such a progressive organization
- ❑ Improves customer relations; get fewer complaints from passengers

❑ Makes me feel like “big brother” is watching me all the time. I dislike the loss of independence

❑ Other: ____

Additional comment or explanation:____
____

B.3) In your experience, what percent of runs on each SLO Transit route do you think run off-schedule? (Please list by routes)	% Off-Schedule When Smart Transit Schedule-Keeping Is Running	% Off-Schedule When Smart Transit Schedule-Keeping Is Not Running	Comments re: particular routes?
1			
2			
3			
4			
5			
6			
7			

Additional comment or explanation: ____

C. Willingness to pay for Smart Transit Features

C.1) Here is another question similar to the one you answered earlier. Again imagine that your employer, to boost morale, provides an on-the-job gift account with $20 per month that you can only use to buy work-related amenities. Now imagine that a SLO Transit budget shortfall requires that the schedule-keeping feature of the Smart Transit System be disabled. Would you be willing to use some of your gift account to chip in with other drivers to restore these features? If so, what’s the maximum amount per month you’d be willing to chip in? (Assume this is the only Smart Transit feature you are chipping in for.)

❑ Not willing to pay anything ❑ $0.50 ❑ $1.00 ❑ $2.00

❑ $3.00 ❑ $4.00 ❑ $5.00 ❑Other (how much?) $_______

D. Do you have any additional comments or suggestions about Smart Transit features we’ve discussed or about any of the other features?

____

____

____

Appendix B Administrator Interview Guide

Interview Guide for SLO Transit Administrators/Managers/Dispatchers

We request your help in providing information to assess the possible benefits of the Smart Transit System components (termed EDAPTS) in use at SLO Transit. These components include: (a) mobile data terminals and automatic vehicle locators on buses; (b) central dispatch software for vehicle tracking; (c) emergency communications; and (d) electronic fare collection.

If you are willing, we would like to ask you a number of structured questions about your experiences and your views about the impacts of these components on SLO Transit operations. Note that the information you provide will be coded anonymously, and you will not be personally identified with any answers you provide.

Are you willing to participate in this interview? (If not, the interview is over. Thank the person for his/her time.)

D. Fare Collection

A.1) Does Automatic Fare Collection (AFC) help you reduce time and expenses associated with cash handling?

- ☐ Yes
- ☐ No

A.2) If the answer is Yes, about how many person-hours do you save in staff time for cash handling (use line with most convenient time period) :

_________________ person-hours per day

_________________ person-hours per week

_________________ person-hours per month

_________________ person-hours per year

A.3) The AFC system provides fare information in a digital format. It makes it easier to prepare reports about daily, weekly, and monthly ridership by route and related revenues. Comparing the administrative costs (in 2006 dollars) of report preparation before and after implementation of the AFC system, what do you think is the reduction in costs?

$____________ per month (= ____ person-hours x $_____/hour burdened wage rate)

E. Benefits to drivers in reducing stress and helping stay on schedule

B.1) The Smart Transit System provides features that may reduce workload and stress on drivers and may increase the number of safe revenue vehicle-miles. How much more incentive payment does the City make to the Contractor (First Transit Inc.) for reductions in accidents following implementation of the Smart Transit System?

- ☐ Not a significant difference
- ☐ Significant, $___________per quarter

B.2) The Smart Transit System helps drivers stay on schedule. This may increase on-time performance and reduce not-on-time penalties. How much does the Smart Transit System help save in not-on-time penalties?

- ☐ Not a significant difference

❑ Significant, $__________per month

B.3) The Smart Transit System helps drivers stay on schedule. It may increase on-time pull-outs and reduce late pull-out penalties. How much does the Smart Transit System help save in late pull-out penalties?

❑ Not a significant difference

❑ Significant, $__________per month

F. **Global Positioning System (GPS)**

C.1a) Does the GPS component of the system enable you to detect if a bus breakdown has occurred?

❑ Yes

❑ No

C.1b) Approximately how often does a breakdown occur (use most convenient time period)?

________________ times a day

________________ times a week

________________ times a month

________________ times a year

C.1c) Based on your experience, how much do you estimate is the typical time saving in response to vehicle breakdowns with and without GPS?

Typical saving in response time with GPS ____________________________(minutes per breakdown)
Additional comment or explanation: ____

C.2) The GPS component of the Smart Transit System may help reduce off-route operations and avoid off-route penalties. How much in off-route penalties is saved by the Smart Transit System?

❑ Not a significant difference

❑ Significant, $____________per month on average

Additional comment or explanation: ____

C.3) The GPS component of the Smart Transit System may help reduce missed services and avoid missed-service penalties. How much in missed-service penalties is saved by the Smart Transit System?

- ❑ Not a significant difference
- ❑ Significant, $____________per month on average

Additional comment or explanation: ____
____
____

C.4) (Ask of dispatch/operations personnel only) Consider all of the times during a typical day when you are required to determine where a particular bus is presently located. There are different possible ways to do this, including the GPS display, radio, and other methods. Please estimate for a typical □ day □ week □ month (check most convenient time period and lead respondent in filling out the following table):

Method used to determine a bus location:	GPS Display	Radio	Other (explain)
Number of times this method used to locate buses in the period:			
Average time taken by this method to locate a bus (minutes):			

Additional comment or explanation: ____
____
____

G. **Schedule Coordination, Reliability and Trip Time**

D.1) Does the Smart Transit System improve schedule coordination at transfer locations?

- ❑ Yes
- ❑ No

Additional comment or explanation: ____
____
____

D.2) Does the Smart Transit System improve overall schedule reliability?

- ❑ Yes
- ❑ No

Additional comment or explanation: ____
____
____

H. Benefits of reducing complaints about service and improving data collection for the National Transit Database

E.1a) The Smart Transit System might improve operational performance and reduce complaints about service. How many complaints per month do you typically receive with and without the Smart Transit System operating?

Typical number of complaints per month with Smart Transit operating: ______________________

Typical number of complaints per month without Smart Transit: ______________________________

Additional comment or explanation: ____
____
____

E.1b) Considering the time and resources involved, how much does the Smart Transit System save (in dollars) from the reduction of staff time to deal with complaints?

❑ Not a significant difference
❑ Significant: $ ____________ per month (= ________ person-hours/month x $______/hour)

Additional comment or explanation: ____
____
____

E.2) The Smart Transit System may help in collecting data for the Federal Transit Administration's (FTA) National Transit Database report (formerly Section 15 data) and reduce your time and effort in preparing periodic NTD reports. How much is saved from reduced staff time in generating NTD data thanks to the Smart Transit System?

❑ Not a significant difference
❑ Significant: $ ____________ per month (= ________ person-hours/month x $______/hour)

Additional comment or explanation: ____
____
____

E.3) How much in late report penalties is typically saved by the use of the Smart Transit System?

❑ Not significant
❑ Significant: $ ____________ per month

Additional comment or explanation: ____
____
____

Appendix: US Bond Rates – September, 2007

http://www.bloomberg.com/markets/rates/index.html; Accessed 9/29/07

U.S. Treasuries

Bills

	MATURITY DATE	DISCOUNT/YIELD	DISCOUNT/YIELD CHANGE	TIME
3-Month	12/27/2007	3.70 / 3.80	0.01 / -.000	09/28
6-Month	03/27/2008	3.93 / 4.07	0.01 / -.000	09/28

Notes/Bonds

	COUPON	MATURITY DATE	CURRENT PRICE/YIELD	PRICE/YIELD CHANGE	TIME
2-Year	4.000	09/30/2009	100-00+ / 3.98	0-00 / -.000	09/28
3-Year	4.500	05/15/2010	101-06 / 4.02	0-00 / -.000	09/28
5-Year	4.250	09/30/2012	100-00½ / 4.25	0-00 / -.000	09/28
10-Year	4.750	08/15/2017	101-08½ / 4.59	0-00 / -.000	09/28
30-Year	5.000	05/15/2037	102-18+ / 4.84	0-00 / -.000	09/28

Municipal Bonds

National Municipal Bond Yields:
Triple-A Rated, Tax-Exempt Insured Revenue Bonds

	CURRENT YIELD	PREVIOUS YIELD	CHANGE IN YIELD	28% EQ YIELD	1 WEEK PRIOR YIELD	1 MONTH PRIOR YIELD	6 MONTH PRIOR YIELD
2-Year	3.59%	3.59%	0.00%	4.99%	3.60%	3.78%	3.65%
5-Year	3.69%	3.66%	0.03%	5.12%	3.67%	3.92%	3.72%
7-Year	3.79%	3.76%	0.03%	5.26%	3.76%	4.06%	3.80%
10-Year	4.02%	3.99%	0.03%	5.58%	3.99%	4.33%	3.96%
15-Year	4.43%	4.43%	0.00%	6.15%	4.42%	4.69%	4.27%
20-Year	4.63%	4.66%	-0.03%	6.43%	4.63%	4.86%	4.41%
30-Year	4.66%	4.69%	-0.03%	6.47%	4.66%	4.89%	4.46%

Notes:

- US Bonds range from 4% (2-year) to 5% (30-year)
- Municipal Bonds range from 3.56% (2-year) to 4.66% (30-year)
- 5% is the most conservative rate within the ranges; it is thus used as the discount rate

Appendix D Passenger Survey Instrument

San Luis Obispo Transit Passenger Survey (2007)

(Note: This draft only shows content; formatting different)

Dear Customer:

We ask for your help in a research project to evaluate some new features of the bus services being provided to you. Please take about 15 minutes to fill out this survey. Your participation involves no risk and is entirely optional; any answers you give will be kept anonymous in order to protect your privacy. If you choose to voluntarily participate, please hand your completed survey to the attendant on board the bus or put it in the box located near the rear exit; you may also mail it back postage-free. (Please do NOT give it to the driver.) In some multiple-choice questions, more than one reply may be given. Some questions ask you to judge how you might respond to imaginary situations; although you may find such questions difficult or even peculiar, please do your best to imagine what you might actually do in the situations described.

If you have questions about this research or would like to see the results when completed, please contact Professor Edward Sullivan at 805-756-2131 or esulliva@calpoly.edu. If you have other questions or concerns about the manner in which the survey is being conducted, you may contact Steve Davis, Chair of the Cal Poly Human Subjects Committee, at 756-2754, or Susan Opava, Dean of Research and Graduate Programs, at 756-1508.
You may separate and keep this cover page for your reference. . . . . .

I got on this bus at (stop location): _________________ To exit this bus at (location): _______________

1. How did you get to the bus stop today?

- ❑ I walked for _____ minutes
- ❑ I drove for _____ minutes
- ❑ I was dropped off; and it took _____ minutes
- ❑ I transferred from another route - Route #; _____

2. How did you know when this bus would leave the bus stop that you used?

- ❑ I have a bus schedule
- ❑ I use this stop often and know the schedule
- ❑ I called the transit system help line to get the time
- ❑ I didn’t know. I arrived when it was convenient hoping the bus would arrive soon
- ❑ I checked the transit website on the internet
- ❑ I checked the electronic bus arrival information displayed at the bus stop (if applicable)

3. How long did you wait at the stop today before the bus arrived?

________________minutes

4. Do you consider the amount of time that you had to wait for the bus to be . . .

- ❑ Acceptable?
- ❑ Too long?

Comments: _______________________________________

5. How often, on average, do you ride the bus?

- ❑ More than 5 times a week
- ❑ 3-5 times a week
- ❑ 1-2 times a week
- ❑ 1-3 times a month
- ❑ Less than once a month

6. In your experience, how often do the buses on this route run on time?

- ❑ Always or almost always
- ❑ Most of the time
- ❑ Sometimes (a quarter to three-quarters of the time)
- ❑ Rarely
- ❑ No opinion or don't know.

7. Imagine that the bus route you are now riding operates at least 10 min. late more than a quarter of the time. If this were the case, would it cause you to ride this bus route less often?

- ❑ It would not change anything
- ❑ I would make some fewer trips (less than a quarter of present bus trips lost)
- ❑ I would make many fewer trips (a quarter to half of present trips lost)
- ❑ I would stop making most trips on this route (more than half of present trips)
- ❑ I'd stop riding the bus altogether
- ❑ I don't know

8. Do you know that SLO buses have an automatic vehicle location system (that tracks where the buses are at all times)?

- ❑ Yes
- ❑ No

9. How many of your typical bus trips either begin or end at bus stops equipped with electronic bus arrival time displays?

- ❑ Most of them (more than half)
- ❑ Many of them (between a quarter and a half)
- ❑ Some of them (less than one in four)
- ❑ None or don't know

10. What is your opinion of the bus arrival time displays located at major bus stops?

- ❑ Very accurate when turned on
- ❑ Fairly accurate when turned on
- ❑ Not accurate
- ❑ No opinion

11a. Does the availability of the electronic bus arrival time display at major bus stops cause you to use the bus more often?

- ❑ Yes
- ❑ No
- ❑ I don't know

11b. If you answered "Yes," how many of your present bus trips would you probably not make if there were no electronic bus arrival time displays anywhere in town?

- ❑ Some (less than a quarter of my present bus trips)
- ❑ Many (between a quarter and half of my present bus trips)
- ❑ Most (more than half my present bus trips)
- ❑ I'd stop riding the bus altogether
- ❑ I don't know

12. Imagine that soon after you boarded this bus the driver announced that the bus will get to your destination 10 minutes behind schedule. However, a special taxi-shuttle is available that will get you to your destination on time.

What's the most you would be willing to pay to get a space on this special shuttle? (Note: this isn't going to happen. This question is to estimate your value of time.)

- ❑ Not willing to pay anything ❑ $0.25
- ❑ $0.50 ❑ $1.00
- ❑ $1.50 ❑ $2.00
- ❑ $3.00 ❑ $5.00
- ❑ Other (please specify) $ ______________________

13a. Now imagine that just before starting your present trip, you learned that the bus service shut down due to a sudden strike. However, a limited capacity taxi-shuttle is available that will get you to your destination at least as fast as the bus. What's the most you would be willing to pay to guarantee yourself a space on this taxi-shuttle? (Note: this isn't expected to happen either. This question is to estimate the importance of trips being made.)

- ❑ Not willing to pay anything ❑ $1.00
- ❑ $0.25 ❑ $1.50
- ❑ $0.50 ❑ $2.00
- ❑ $0.75 ❑Other (how much?) $_______

13b. In the situation described above, if neither the bus service nor the pretend taxi-shuttle were available, how would you get to your present destination?

- ❑ Walk or bike
- ❑ Drive
- ❑ Ask a friend or family member for a ride
- ❑ I wouldn't make this trip if the bus weren't available
- ❑ Other (describe): ____________________________

14. Finally, imagine that budget cutbacks force the city to replace all of its existing electronic bus arrival time displays with devices that provide the same information for a fee. How much would you have been willing to pay for reliable bus arrival time information for the trip you are presently taking? (Note that such a change is not being considered. This question is to estimate the value of the information provided by the displays.)

- ❑ Not willing to pay anything ❑ $1.00
- ❑ $0.25 ❑ $1.50
- ❑ $0.50 ❑ $2.00
- ❑ $0.75 ❑ Other (how much?) $_______

15. Do you have access to a car that you could have used for the bus trip you are making today?

- ❑ Yes
- ❑ No

16. Your gender:

- ☐ Male
- ☐ Female

17. Are you:

- ☐ A student or trainee in the SLO area
- ☐ Employed full-time in the SLO area
- ☐ Employed part-time in the SLO area
- ☐ Other resident of the SLO area
- ☐ Temporarily visiting the SLO area from elsewhere
- ☐ Other: ______________________________

18. Your age group:

- ☐ Under 16
- ☐ 16-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 66-75
- ☐ Over 75

Thank you for your help. Do you have any comments or suggestions regarding local transit services?

____

____

____

____

____